CALIFORNIA MINERAL PRODUCTION FOR 1922

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LLOYD L. ROOT — State Mineralogist

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CALIFORNIA MINERAL PRODUCTION FOR 1922

BY

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September, 1923.

To His Excellency, THE HONORABLE FRIEND WM. RICHARDSON,
Governor of the State of California.

SIR: I have the honor to herewith transmit Bulletin No. 93 of the State Mining Bureau, being the annual report of the statistics of the mineral production of California.

The remarkable variety, total valuation, and wide distribution of many of our minerals revealed herein show California's importance as a producer of commercial minerals among the states of the Union.

Respectfully submitted.

LLOYD L. ROOT,
State Mineralogist.

LETTER OF INTRODUCTION.

It is the endeavor of the staff of the State Mining Bureau, in these annual reports of the mineral industries of California, to so compile the statistics of production that they will be of actual use to producers and to those interested in the utilization of the mineral products of our state, while at the same time keeping the individual's data confidential. In addition to the mere figures of output, we have included descriptions of the uses and characteristics of many of the materials, as well as a brief mention of their occurrences.

The compilation of accurate and dependable figures is an extremely difficult undertaking, and the State Mineralogist takes the opportunity of here expressing his appreciation of the cooperation of the producers in making this work possible. A fuller appreciation of the value of early responses to the requests sent out in January will result in earlier completion of the manuscript. Statistics lose much of their value if their publication is unnecessarily delayed.

Some of the data relative to properties and uses of many of the minerals herein described are repeated from preceding reports, as it is intended that this annual statistical bulletin shall be somewhat of a compendium of information on California's commercial minerals and their utilization.

LLOYD L. ROOT,
State Mineralogist.

MINERAL INDUSTRY, CALIFORNIA, 1922.

DATA COMPILED FROM DIRECT RETURNS FROM PRODUCERS IN ANSWER TO INQUIRIES SENT OUT BY THE CALIFORNIA STATE MINING BUREAU, FERRY BUILDING, SAN FRANCISCO, CALIFORNIA.

CHAPTER ONE.

The total value of the mineral output of California for the year 1922 was $245,183,826 being a decrease of $22,973,646 from the 1921 total of $268,157,472. There were fifty-three different mineral substances, exclusive of a segregation of the various stones grouped under gems; and all of the fifty-eight counties of the state contributed to the list.

As revealed by the data following, herein, the salient features of 1922 compared with the preceding year, were: The continued increase in petroleum yield, although of lower prices per barrel; increases in copper, lead, natural gas, brick and tile, and crushed rock; and decreases in gold, silver, cement, and petroleum values. The net result was a decrease in the grand total of all groups of nearly twenty-three million dollars, as stated above. Petroleum accounted for a decrease of $29,756,960 in total value, although there was an increase in quantity of approximately 26,000,000 barrels.

Of the metals: copper increased from 12,088,053 pounds worth $1,559,358 to 22,883,987 pounds worth $3,090,582; lead, from 1,149,051 pounds and $51,707 to 6,511,280 pounds and $358,120; zinc, quicksilver, platinum, and iron ore also showed increases. Gold decreased from $15,704,822 to $14,670,346, in spite of which in 1922 California accounted for approximately 30% of the gold output of the United States.

Of the structural group: brick and tile increased in value from $5,570,875 to $7,994,991; miscellaneous stone (comprising crushed rock, sand and gravel, paving blocks) from $7,834,640 to $10,377,783; magnesite, lime, marble, and onyx also increasing; cement although increasing from 7,404,221 barrels to 8,962,135 barrels in output, decreased from $18,072,120 to $16,524,056 in value. Slate again joined the active list with a small yield.

In the 'industrial' group, there were a number of fluctuations, the more important increases being shown by mineral water, pottery clay, gypsum, and pyrites; and decreases by diatomaceous earth, and limestone. Two new items were added in 1922 to this list, not previously produced commercially in California, namely: shale oil and sillimanite. In the saline group, potash and soda increased, with borates, magnesium salts, salt, and calcium chloride, decreasing.

The figures of the State Mining Bureau are made up from reports received direct from the producers of the various minerals. Care is

exercised in avoiding duplication, and any error is likely to be on the side of under- rather than over-estimation.

California yields commercially a greater number and variety of mineral products than any state in the United States, and probably more than any other equal area elsewhere of the earth. The total annual value of her output is surpassed by not more than four or five others, and those usually the great coal states of east of the Mississippi. Of one item, at least, borax, California has long been the sole producer; and for many years was also the sole domestic source of chromite and magnesite. We lead all other states in the production of gold, quicksilver, and platinum; and have alternated in the lead with Colorado in tungsten, and with Oklahoma in petroleum.

The following table shows the comparative yield of mineral substances of California for 1921 and 1922, as compiled from the returns received at the State Mining Bureau, San Francisco, in answer to inquiries sent to producers:

Substance	1921 Amount	1921 Value	1922 Amount	1922 Value	Increase + Decrease— Value
Asbestos	410 tons	$19,275	50 tons	$1,800	$17,475—
Barytes	901 tons	4,809	3,370 tons	18,925	14,116+
Bituminous rock	8,298 tons	43,192	4,624 tons	13,570	29,622—
Borates	50,136 tons	1,096,326	[a]39,087 tons	1,068,025	28,301—
Calcium chloride	683 tons	22,980	c	c	c —
Cement	7,404,221 bbls.	18,072,120	8,962,135 bbls.	16,524,056	1,548,064—
Brick and tile		5,570,875		7,994,991	2,424,116+
Chromite	347 tons	6,870	379 tons	6,334	536—
Clay (pottery)	225,120 tons	362,172	277,232 tons	473,184	111,012+
Coal	12,467 tons	63,578	27,020 tons	135,100	71,522+
Copper	12,088,053 lbs.	1,559,358	22,883,987 lbs.	3,090,582	1,531,224+
Dolomite	31,195 tons	99,135	52,469 tons	114,911	15,776+
Feldspar	4,349 tons	28,343	4,587 tons	37,109	8,766+
Fullers' earth	1,185 tons	8,295	6,696 tons	48,756	40,461+
Gems		10,954		1,312	9,642—
Gold		15,704,822		14,670,346	1,034,476—
Granite		725,901		676,643	49,258—
Graphite	b	b	c	c	c +
Gypsum	37,412 tons	78,875	47,081 tons	188,336	109,461+
Infusorial and diatomaceous earths	b	b	c	c	c —
Iron ore	1,970 tons	12,030	3,588 tons	18,868	6,838+
Lead	1,149,051 lbs.	51,707	6,511,280 lbs.	358,120	306,413+
Lime	463,534 bbls.	610,619	578,748 bbls.	671,747	61,128+
Limestone	75,921 tons	305,912	84,382 tons	282,181	23,731—
Lithia	b	b	c	c	c —
Magnesite	47,837 tons	511,102	55,637 tons	594,665	83,563+
Magnesium salts	4,153 tons	106,140	3,036 tons	89,788	16,352—
Manganese ore	1,005 tons	12,210	540 tons	7,650	4,560—
Marble	30,232 cu. ft.	98,395	38,321 cu. ft.	127,792	29,397+
Mineral paint	446 tons	4,748	1,620 tons	13,277	8,529+
Mineral water	3,446,278 gals.	367,476	4,276,346 gals.	486,424	118,948+
Natural gas	67,043,797 M. cu. ft.	4,704,678	103,628,027 M. cu. ft.	6,990,030	2,285,352+
Onyx	2,569 cu. ft.	1,291	10,950 cu. ft.	3,320	2,026+
Petroleum	112,599,860 bbls.	203,138,225	138,468,222 bbls.	173,381,265	29,756,960—
Platinum	613 fine oz.	58,754	795 fine oz.	90,288	31,534+
Potash	14,806 tons	390,210	17,776 tons	584,388	194,178+
Pumice and volcanic ash	406 tons	6,310	613 tons	4,248	2,062—
Pyrites	110,025 tons	473,735	151,381 tons	570,425	96,690+
Quicksilver	3,157 flasks	140,666	3,466 flasks	191,851	51,185+
Salt	197,989 tons	832,702	223,238 tons	819,187	13,515—
Sandstone	10,150 cu. ft.	2,112	900 cu. ft.	1,100	1,012—
Shale oil			c	c	c +
Silica (sand and quartz)	10,569 tons	49,179	9,874 tons	31,016	18,163—
Sillimanite			c	c	c +
Silver		3,629,223		3,100,065	529,158—
Slate			c	c	c +
Soapstone and talc	8,752 tons	130,078	13,378 tons	197,186	67,108+
Soda	14,828 tons	438,996	20,084 tons	573,661	134,665+
Stone, miscellaneous[d]		7,834,640		10,377,783	2,543,143+
Zinc	846,181 lbs.	42,309	3,034,430 lbs.	172,963	130,654+
Unapportioned		[b]726,122		[c]380,558	315,564—
Total values		$268,157,472		$245,183,826	
Net decrease					$22,973,646—

[a]Recalculated to 40% 'anhydrous boric acid' equivalent.

[b]Unapportioned—includes graphite, diatomaceous earth, and lithia.

[c]Unapportioned—includes calcium chloride, graphite, diatomaceous earth, lithia, shale oil, sillimanite, and slate.

[d]Includes macadam, ballast, rubble, riprap, paving blocks, sand, gravel, and grinding-mill pebbles.

The following table shows the comparative value of the mineral production of the various counties in the state, for the years 1921 and 1922:

County	1921	1922
Alameda	$1,353,690	$2,041,454
Alpine	925	2,800
Amador	2,368,464	2,479,063
Butte	669,830	720,625
Calaveras	1,525,201	1,502,883
Colusa	80,438	75,934
Contra Costa	1,622,732	2,397,312
Del Norte	6,029	6,261
El Dorado	112,756	184,525
Fresno	19,498,503	10,853,433
Glenn	103,197	91,250
Humboldt	138,597	125,613
Imperial	182,818	188,739
Inyo	1,460,218	2,137,681
Kern	100,840,933	68,551,002
Kings	5,722	6,806
Lake	174,389	48,289
Lassen	83,485	27,327
Los Angeles	31,704,941	62,751,671
Madera	467,667	476,264
Marin	318,776	403,099
Mariposa	342,601	226,832
Mendocino	44,722	20,526
Merced	33,550	157,579
Modoc	36,650	16,018
Mono	56.876	86,863
Monterey	170,155	255,319
Napa	195,239	312,270
Nevada	2,641,081	2,966,005
Orange	47,499,030	38,926,087
Placer	479.070	405,975
Plumas	1,798,461	3,314,[illegible]98
Riverside	4,883,898	3,243,917
Sacramento	2,394,894	2,189,562
San Benito	1,386,093	1,794,248
San Bernardino	9,375,540	8,547,900
San Diego	501,393	656,807
San Francisco	41,562	65,409
San Joaquin	474.378	473,395
San Luis Obispo	129,791	141,470
San Mateo	257,092	243,934
Santa Barbara	10,190,929	4,613,378
Santa Clara	750,708	894.036
Santa Cruz	4,080,885	3,608.805
Shasta	841,262	1,513,591
Sierra	620.361	1,770,626
Siskiyou	93,147	101,463
Solano	3,030,198	3,108.114
Sonoma	175.551	221,941
Stanislaus	236,207	452,167
Sutter	54	97
Tehama	30,820	9.388
Trinity	456,882	197.937
Tulare	552,234	371.845
Tuolumne	554.483	764,938
Ventura	6,245.269	5,837,078
Yolo	14,829	13.431
Yuba	4,872.266	2,588,316
Total values	$268,157,472	$245,183,826

Total Mineral Production of California, by Years.

The following tabulation gives the total value of mineral production of California by years since 1887, in which year compilation of such data by the State Mining Bureau began. At the side of these figures the writer has placed the values of the most important metal and non-metal items—gold and petroleum.

In the same period copper made an important growth beginning with 1897 following the entry of the Shasta County mines, and more recently Plumas County. Cement increased rapidly from 1902, while crushed rock, sand and gravel as a group parallels the cement increase. Quicksilver has been up and down. Mineral water and salt have always been important items, but the values fluctuate. Borax has increased materially since 1896. War-time increases, 1915–1918, were shown by chromite, copper, lead, magnesite, manganese, silver, tungsten and zinc. Most of these, except silver, have since declined; with structural materials and copper increasing in 1920–1922.

Total Mineral Production of California by Years, Since 1887.

Year	Total value of all minerals	Gold, value	Petroleum, value
1887	$19,785,868	$13,588,614	$1,357,144
1888	19,469,320	12,750,000	1,380,666
1889	16,681,731	11,212,913	368,048
1890	18,039,666	12,309,793	384,200
1891	18,872,413	12,728,869	401,264
1892	18,300,168	12,571,900	561,333
1893	18,811,261	12,422,811	608,092
1894	20,203,294	13,923,281	1,064,521
1895	22,844,663	15,334,317	1,000,235
1896	24,291,398	17,181,562	1,180,793
1897	25,142,441	15,871,401	1,918,269
1898	27,289,079	15,906,478	2,376,420
1899	29,313,460	15,336,031	2,660,793
1900	32,622,945	15,863,355	4,152,928
1901	34,355,981	16,989,044	2,961,102
1902	35,069,105	16,910,320	4,692,189
1903	37,759,040	16,471,264	7,313,271
1904	43,778,348	19,109,600	8,317,809
1905	43,069,227	19,197,043	9,007,820
1906	46,776,085	18,732,452	9,238,020
1907	55,697,949	16,727,928	16,783,943
1908	66,363,198	18,761,559	26,566,181
1909	82,972,209	20,237,870	32,398,187
1910	88,419,079	19,715,440	37,689,542
1911	87,497,879	19,738,908	40,552,088
1912	88,972,385	19,713,478	41,868,344
1913	98,644,639	20,406,958	48,578,014
1914	93,314,773	20,653,496	47,487,109
1915	96,663,369	22,442,296	43,503,837
1916	127,901,610	21,410,741	57,421,334
1917	161,202,962	20,087,504	86,976,209
1918	199,753,837	16,529,162	127,459,221
1919	195,830,002	16,695,955	142,610,563
1920	242,099,667	14,311,043	178,394,937
1921	268,157,472	15,704,822	203,138,225
1922	245,183,826	14,670,346	173,381,265
Totals	$2,751,150,349	$602,218,554	$1,365,753,916

CHAPTER TWO.

FUELS.

Among the most important mineral products of California are its fuels. This subdivision includes coal, natural gas, and petroleum, the combined values of which made up nearly 75% of the state's entire mineral output for the year 1922.

There are deposits of peat known in several localities in California, small amounts of which are used as a fertilizer, and in stock-food preparations, but none has as yet been recorded as utilized for fuel.

Comparison of values during 1921 and 1922 is shown in the following table:

	1921		1922		Increase+ Decrease—
	Amount	Value	Amount	Value	Value
Coal	12,467 tons	$63,578	27,020 tons	$135,100	$71,522+
Natural gas	67,043,797 M. cu. ft.	4,704,678	103,628,027 M. cu. ft.	6,990,030	2,285,352+
Petroleum	112,599,860 bbls.	203,138,225	138,468,222 bbls.	173,381,265	29,756,960—
Total value		$207,906,481		$180,506,395	
Net decrease					$27,400,086—

COAL.

Bibliography: State Mineralogist Reports VII, XII, XIII, XIV, XV, XVII, XVIII, pp. 152-157. U. S. G. S., Bulletins 285, 316, 431, 471, 581; An. Rep. 22, Pt. III.

Coal has been produced in California since as early as 1860, and until the development of crude oil was an important factor in the mineral industry of the state. As most of it is lignite, the quality is generally poor as compared with other coals on the Pacific Coast markets. However, in competition with fuel oil, coal of all grades has had to take second place. Besides the counties noted below as showing a commercial production last year, workable bodies of coal are also known in several others, including Alameda, Amador, Contra Costa, Mendocino, Shasta and Siskiyou. Some coal has also been produced, in the past, in Fresno and Orange counties. Development work is at present being done on a body of coking coal near Dos Rios in Mendocino County.

During 1922, production was reported from Monterey and Riverside counties totaling 27,020 tons, valued at $135,100. The increase is due to the reopening of the Stone Canyon Mine in Monterey County, which was operated up to August 1st when it was shut down. The Riverside County output was utilized only for local purposes at the mine.

Total Coal Production of California.

The very considerable output of coal in the years previous to 1883 was almost entirely from the Mount Diablo district, Contra Costa County. Later, the Tesla Mine in Corral Hollow, Alameda County, was an important producer for a few years. The following tabulation gives the annual tonnages and values, according to available records:

Coal Output and Value by Years.

Year	Tons	Value	Year	Tons	Value
1861	6,620	$38,065	1893	72,603	$167,555
1862	23,400	134,550	1894	59,887	139,862
1863	43,200	248,400	1895	79,858	193,790
1864	50,700	291,525	1896	70,649	161,335
1865	60,530	348,048	1897	87,449	196,255
1866	84,020	483,115	1898	143,045	337,475
1867	124,690	716,968	1899	160,941	420,109
1868	143,676	826,137	1900	176,956	535,531
1869	157,234	904,096	1901	150,724	401,772
1870	141,890	815,868	1902	88,460	248,622
1871	152,493	876,835	1903	93,026	265,383
1872	190,859	1,097,439	1904	79,062	376,494
1873	186,611	1,073,013	1905	46,500	144,500
1874	215,352	1,238,274	1906	24,850	61,600
1875	166,638	958,169	1907	23,734	55,849
1876	128,049	736,282	1908	18,496	55,503
1877	107,789	619,787	1909	49,389	216,913
1878	134,237	771,863	1910	11,033	23,484
1879	147,879	850,304	1911	11,047	18,297
1880	236,950	1,362,463	1912	14,484	39,092
1881	140,000	805,000	1913	25,198	85,809
1882	112,592	647,404	1914	11,859	28,806
1883	76,162	380,810	1915	10,299	26,662
1884	77,485	309,950	1916	4,037	7,030
1885	71,615	286,460	1917	3,527	7,691
1886	100,000	300,000	1918	6,343	16,149
1887	50,000	150,000	1919	2,983	8,203
1888	95,000	380,000	1920	2,078	5,450
1889	121,280	288,232	1921	12,467	63,578
1890	110,711	283,019	1922	27,020	135,100
1891	93,301	204,902			
1892	85,178	209,711	Totals	5,204,145	$23,080,588

The tonnages in the above table for the years 1861-1886 (incl.) are taken from the U. S. Geological Survey, "Mineral Resources of the U. S., 1910," p. 107. The values assigned for the years previous to 1883 are those given by W. A. Goodyear (Mineral Res., 1882, pp. 93-94), being an average of $5.75 per ton. From 1887 to date the figures are those of the California State Mining Bureau.

NATURAL GAS.

Bibliography: State Mineralogist Reports VII, X, XII, XIII, XIV. Bulletins 3, 16, 19, 69, 73, 89. Monthly Summary, Oil & Gas Supervisor, Dec. 1919; Aug. 1922; Mar. 1923.

Statistics on the production of natural gas in California are in a considerable degree difficult to arrive at, as much of it that is utilized directly at the wells for heating, lighting, and driving gas engines is not measured. Hence, it is necessary to approximate the output of many of the operators in the oil fields, estimated on the number of lights, and on the number and horsepower of gas engines and steam boilers thus operated. The figures here given are for gas utilized locally and also that sold for distribution to consumers; and we consider are not over-estimated, particularly in the six oil-producing counties. It must be remembered that several of our important oil fields are removed many miles from the site of any other industry, and that the gathering of small amounts of gas and transporting it for any considerable distance may not always be profitable. Wherever feasible, casing-head gas is used in driving gas engines for pumping and drilling, and in firing the boilers of steam-driven plants.

The most notable gas developments in California in recent years have been in the Elk Hills and Buena Vista Hills in Kern County, northeast of the Midway district, and in the new oil fields at Long Beach and Santa Fe Springs in Los Angeles County. The yield of natural gas in the Los Angeles district is so great that large amounts are going to waste, although every effort is being made to utilize as much as possible for domestic and industrial purposes.

Several counties produce gas which is not accompanied by oil, particularly Sacramento and San Joaquin, where it is mixed with manufactured gas for domestic service. The Tulare Lake district in Kings and Tulare counties also does not yield oil.

The subject of natural gas production and its utilization in the southern part of the state has recently been covered exhaustively and in detail by Mr. H. L. Masser[1], gas engineer for the Railroad Commission of California. A portion of his summary and conclusions is quoted herewith:

"SUMMARY OF NATURAL GAS FIELDS.

"The Midway and Elk Hills fields are now producing sufficient gas adequately to meet all demands for field use, for the City of Bakersfield, San Joaquin electric plants, and for the full capacity of the Midway transmission line to Los Angeles. Therefore further developments would not find a ready market for the gas at this time.

"The Santa Maria and Ventura fields are adequately supplying local requirements and in no way affect operations in the Los Angeles district.

"A very large surplus of gas now exists over present or proposed pipe line capacities in Long Beach and Santa Fe Springs, and the same condition quite likely will soon be true of Huntington Beach. Richfield, Montebello and Coyote Hills show a decline in production, but this is much more than compensated by new production at Long Beach and Santa Fe Springs. All of the fields mentioned in this paragraph directly or indirectly supply gas to the Los Angeles City district, and the supply available from Long Beach and Santa Fe Springs is entirely a matter of pipe lines and compressor equipment.

"The following tabulation sets forth total natural gas production by fields, as analyzed in Tables No. 1 to 8 inclusive, at the end of 1922.

"Natural Gas Production—Mcf. per day.

"Midway, Elk Hills, Tupman	136,165
Miscellaneous San Joaquin Valley Fields	3,265
Coyote Hills	12,080
Montebello	12,880
Richfield	31,600
Brea-Olinda	8,300
Long Beach	228,915
Santa Fe Springs	72,170
Huntington Beach	20,450
Salt Lake	1,700
Ventura	6,480
Santa Maria	8,760
Casmalia and Cat Canyon	720
Total	543,180

"The above figure shows the total amount of natural gas production actually accounted for, and it is quite safe to estimate that there is a further production of about 50,000 Mcf., of which no record has been obtained, making a total gas production in the state of about 600,000 Mcf. per day. Only a small part of this can be considered as available to distributing companies, as there are deductions to be made for the requirements of the producer, in addition to the very large deductions necessary to cover low pressure gas wasted from widely scattered wells and gasoline absorption plants. It must be borne in mind that natural gas production is rapidly changing from day to day, and in a large number of instances it is not economically sound to construct pipe lines to certain wells to collect the gas, as the supply might be so reduced by the time the line is in that a reasonable return upon the investment could not be realized.

"Gas wastage is now most general in the Long Beach field. Of the total production of 230,000 Mcf. only about 30,000 Mcf. is delivered to distributing companies, and under 15,000 Mcf. used for lease and drilling purposes, making a total of 45,000 Mcf. of gas conserved. In addition about 90,000 Mcf. of gas is put through extraction plants to recover the gasoline. The only possibility of utilizing a portion of this gas now wasted into the air would be through the develoment of a greater market for

[1]Masser, H. L., Natural gas production and utilization in southern California, Cal. State Min. Bur., Summary of Cal. Oil Field Operations, Vol. 8, No. 9, pp. 5-66, Mar. 1923.

gas in Los Angeles by a change of the present standard for domestic service. This question is discussed later with estimates of probable requirements.

"Pipe Line and Compressor Plant Facilities.

"In most cases the availability of gas to local markets is a question of pipe line and compressor plant facilities. A brief description of the principal gas transmission lines and compressor plants is set forth in the following paragraphs:

"MIDWAY FIELD.

"Midway Gas Company has constructed a very comprehensive system of gathering lines in the field, which delivers high pressure gas to its Bakersfield lines and low pressure gas to its large compressor plant which raises the pressure to 400 pounds for transmission to Los Angeles. From Standard Oil Company's Elk Hills leases, Midway Gas Company has laid an 8-inch line and also a 10-inch line for delivering the large volume of gas produced there to Elk Hills Junction for transmission to Bakersfield, or to the Midway field and Los Angeles; and through a 6-inch line to the McNee compressor plant, where the gas enters the main gathering line system. An 8-inch line about 12 miles in length, running northward from the Hay lease, has been laid to supply the Buttonwillow plant of San Joaquin Light and Power Company.

"The Bakersfield transmission line may be considered as starting at a point known as Elk Hills Junction, four miles south of the Hay lease. From this point there has been laid seven miles of 8-inch line, to which is connected 18½ miles of 10-inch welded line extending to a point about three miles northwest of Bakersfield. From this latter point the line is continued with 12-inch pipe a distance of about 2½ miles, and further extensions of 6-inch and 8-inch lines serve the Kern River oil fields with industrial gas. Paralleling the 10-inch welded line is the old 6-inch line originally installed by the California Natural Gas Company. The combined capacity of the two lines is about 24,000 Mcf. at 350 pounds pressure; the previous lines to Bakersfield had a capacity of only 10,000 Mcf.

"From the Midway compressor plant there extends 110 miles of 12-inch line to Glendale for supplying Los Angeles. For a distance of thirty miles at each end of the line there has been laid a second parallel loop of 12-inch welded pipe which increases the delivery capacity to the former line about 8000 Mcf. daily. The combined lines now have an average intake capacity of 35,000 Mcf. and delivery of about 31,000 Mcf. at Glendale with small sales along the line. The Midway compressor plant consists of four 1000 horsepower Cooper twin tandem gas engines direct connected to compressor cylinders and three similar single units of 500 horsepower each."

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"An elaborate system of lines covers the Midway field where much gas is sold for oil well operations. Midway Gas Company furnishes gas in wholesale to West Side Natural Gas Company for use in Taft, Maricopa and Fellows. Other wholesale measurements are made to the Bakersfield Steam Plant of San Joaquin Light and Power Corporation and also the Buttonwillow plant. The line supplying this runs directly north from the Elk Hills field. Little industrial load is obtained on the Bakersfield transmission line between the Midway fields and the town of Bakersfield due to the nature of the country traversed."

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"COYOTE HILLS LINE.

"The original line from the Coyote Hills field was completed about the first of 1916, being an 8-inch welded line fourteen miles in length, delivering gas to Lynwood Meter Station south of Los Angeles City. This line operating at a 250 pounds pressure has a maximum capacity of about 11,000 Mcf. Because of the large quantity of gas produced at Coyote Hills in 1917 and 1918, a second 8-inch line was laid at that time, paralleling the first line for half the distance from the field and then branching northward and terminating at Vernon to deliver additional gas to Los Angeles. This second line is now connected with the Midway compressor plant at Santa Fe Springs, which has a capacity of about 6000 Mcf. At Coyote Hills Standard Oil Company has installed compressor plants of about 33,500 Mcf. capacity."

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" * * * These lines are now so interconnected that gas may be transported from one district to another to satisfy load requirements and to permit the most advantageous utilization of the gas. This arrangement is of special advantage during winter periods of heavy gas demand. At the present time over 12,000 Mcf. of gas is delivered via several lines from Richfield to Coyote Hills and thence to Los Angeles."

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"Extending northwesterly from Coyote Hills, Southern Counties Gas Company has built a 4-inch line taking gas from that source to its Whittier and Montebello district, and further continuance of this line has been made to Monrovia. Recently a new 8 and 10-inch line has been laid by Southern Counties Gas Company from La Habra to Montebello. This line is tied in to the Company's Santa Fe Springs system and because of its many interconnections, makes a very flexible operating system. With the development of gas in the Montebello field, a new Monrovia line was built, as well as a 6-inch line for delivering surplus gas to Southern California Gas Company at Laguna. Compressor plant equipment in this field is 15,000 Mcf. on Standard Oil Company leases.

"The Orange County districts of Southern Counties Gas Company were first served through a 6-inch line from Coyote Hills extending to Anaheim and Santa Ana with branch lines to adjacent towns, including a long extension to Newport Beach.

"BREA-POMONA LINE.

"This is an 8-inch line about 12 miles in length which takes its supply from Southern Counties Gas Company's compressor plant at Brea (gas being obtained from the local field and Richfield). The capacity of this plant is 5000 Mcf. From Pomona gas is delivered to immediately adjacent towns and further westward as far as Covina and Azusa. Since the latter part of 1919 gas has also been furnished to the Chino-Colton line of Southern California Gas Company.

"RICHFIELD LINES.

"Upon the development of large quantities of gas in this district Southern Counties Gas Company connected this field with its Orange county lines from Coyote Hills. Later the Industrial Fuel Supply Company entered the field and built a compressor plant, which now has a capacity of 13,000 Mcf., and laid an 8-inch welded line to the City of Long Beach, a distance of approximately 22 miles. This line transmits gas for Union Oil Company's refinery at Wilmington, and provides a material portion of the supply to Long Beach, Wilmington and San Pedro. Standard Oil Company has constructed, upon its Kraemer lease, a plant of 13,000 Mcf. delivering gas to Industrial Fuel Supply Company and for various purposes about the lease. In order to promote the better utilization of gas produced in the Richfield District, Industrial Fuel Supply Company has recently laid a 10-inch line connecting its plant with the two lines of Midway Gas Company at Coyote Hills, and at present daily deliveries over this line amount to about 12,500 Mcf. Southern Counties Gas Company has also connected its Brea Station with its 4-inch line to Whittier. By arrangement of lines it is possible, within certain limits, to make available gas from any of the fields to any of the districts served, provided pressures are adequate.

"SANTA FE SPRINGS LINE.

"Midway Gas Company has constructed twelve miles of 16-inch welded line to deliver gas from the Santa Fe Springs field direct to the gas works of Southern California Gas Company. This is one of the biggest steps recently taken for materially increasing the quantity of natural gas available to Los Angeles City. Under relatively low pressures this line has a capacity of 25,000 Mcf. Its full operation will depend very largely upon the installation of field compressor plants for gathering low pressure gas from the various leases, or the development of more high pressure dry gas in the Santa Fe Springs field. Standard Oil Company is now constructing a compressor plant of 6000 Mcf. to 8000 Mcf. capacity.

"LONG BEACH LINES.

"Southern California Gas Company has for a long time operated an 8-inch line from its gas generating plant in Los Angeles to Long Beach, this line first furnishing artificial gas. Due to recent developments in the Long Beach oil field Southern Counties Gas Company is now able to meet all requirements of the Long Beach district for that source, so this 8-inch line is now principally used for delivering gas northward to Los Angeles from the Lynwood and Vernon Meter Stations. Midway Gas Company has just completed a 4-unit compressor plant at Long Beach for delivering gas to the General Pipe Line Company's Cherry Pump Station. The surplus above the General Pipe Line Company's requirements is delivered to Southern California Company's 8-inch line at Compton. A connection between this line and the Redondo line has recently been made, thereby permitting the delivery of gas from Long Beach oil field to Torrance and Redondo Beach.

"Industrial Fuel Supply Company is now installing a 12-inch unit compressor plant in the Long Beach oil field for taking low pressure gas from leases of Shell Company and others for delivery to Southern Counties Gas Company's Long Beach district. At present there is considerable sale of gas for oil field purposes.

"REDONDO LINE.

"The Redondo line is a 12-inch line operated by Southern California Gas Company. An 8-inch line branches off to the south furnishing large amounts of gas for industrial purposes in Torrance. From Redondo Beach the line has been extended northerly to Playa Del Rey for delivering gas to the Santa Monica Bay district of Southern Counties Gas Company. This district is nominally served with mixed gas and in order to provide this service a mixed gas line has been laid from Southern California Gas Company's holder at Slauson and Western Avenue to El Segundo.

"HUNTINGTON BEACH LINE.

"At Huntington Beach is an 8-inch line laid by Murphy-Dillon Company at the outset of active drilling operations in the Huntington Beach oil field. Much disappointment was experienced in regard to this line as very little gas was developed by the early drilling at Huntington Beach, and the line was used to take gas into the field rather than out of it. Present indications point to large gas production and it is expected that this line will soon gecome operative for delivering gas to other districts to the north. Standard Oil Company is now operating a private line out of this field and also maintains a compressor station of 12-units, delivering over 10,000 Mcf. for use upon its own properties.

"COLTON-CHINO LINE.

"The Colton-Chino line is an 8-inch line twenty-two miles in length laid by Southern California Gas Company in 1919 for supplying natural gas to its San Bernardino Valley division. Gas is purchased at Chino from Southern Counties Gas Company, this being surplus above the requirements of its Pomona district. The demand for gas in the San Bernardino district is now about 3000 Mcf. with a

possible peak of 4000 Mcf. During the winter period Southern Counties Gas Company has not a sufficient supply available. From Colton, which is the central distributing point, Southern California Gas Company has laid 6-inch lines to Riverside and San Bernardino and a 4-inch line to Redlands. A 4-inch line also taps the Chino-Colton line to supply Corona. All of these transmission mains are fully adequate to meet their local demands. Any inadequacy results from inability of Southern Counties Gas Company to supply present demands, which are materially in excess of sales contracted for between the two companies.

"SAWTELLE LINE.

"The Sawtelle line is really a part of the Los Angeles City district system and is a 6-inch mixed gas line from Southern California Gas Company's gas plant to Sawtelle, and provides the principal supply of the Santa Monica Bay district. This line has now become inadequate making necessary further delivery at El Segundo, as above referred to. Plans now being prepared contemplate the replacement of a portion of this line this year with a 16-inch line through Los Angeles City.

"LOS ANGELES CITY DISTRICT TRUNK LINES.

"Because of the extremely rapid growth of Los Angeles and immediately adjacent towns, all companies have had great difficulty in rendering proper service. In order to meet the demands the Los Angeles Gas Company has recently completed the installation of 16-inch welded lines to Hollywood, Pasadena, Alhambra and the southern part of the city. These new lines permit the transmission of much greater volume of gas than previously possible and a much lower pressure. Southern California Gas Company has laid 8-inch lines from its Western Avenue holder to furnish mixed gas to Santa Monica, and has also constructed lines connecting its system with Long Beach oil field. Additional compressors and holders discussed later have been added to the plants. The following is a summary of gas available to Los Angeles City.

"Summary of Natural Gas Available to Los Angeles City.

	Mcf.
"By Midway Gas Company:	
From Midway field through Glendale	31,000
From Coyote Hills-Southern Counties Gas Co.	2,500
From Richfield, through Coyote Hills-Industrial Fuel Supply Company	12,500
From Santa Fe Springs*	25,500
From Long Beach through Compton	10,000
"By Southern California Gas Company:	
From Salt Lake fields	1,250
Total natural gas delivered to Los Angeles City	82,750

*Does not include oil field and Fullerton line deliveries amounting to about 9500 Mcf.

"At present this gas is being distributed about equally between Southern California Gas Company and Los Angeles Gas Company."

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"General Summary and Conclusions.

"This Report may be most readily summed up by recapitulation of the principal divisions of the discussion and short comments in regard to each. It has been the desire to study as fully as possible the matter of natural gas production and utilization in the various oil fields and to give this subject special attention, as at the present time total gas production and wastage have increased to immense proportions and are attracting much public interest.

"NATURAL GAS PRODUCTION.

"Estimated total gas production in the oil fields of this state now amounts to approximately 540,000 Mcf. per day, of which amount about 100,000 Mcf. is used by the producer, 200,000 Mcf. is sold to distributing companies, and the balance of 240,000 Mcf. is being wasted. This wastage is equivalent to 45,000 barrels of oil per day and of this amount 70 per cent is in the Long Beach field. An immense quantity of gas amounting to about 230,000 Mcf. is produced in Long Beach field at the present time. However, upon completion of drilling in the productive gas area it appears reasonable to believe there will be a rapid decline in the total gas production of the field, and within a year and a half it is quite possible that only 30,000 Mcf. to 40,000 Mcf. will then be available to distributing companies. The Santa Fe Springs field appears to be offering somewhat better potentialities for continued gas production in large commercial quantities as there has been found a very productive high pressure gas formation. Present developments at Huntington Beach point to greatly increased gas production there within the very near future, and if possible an attempt should be made to formulate measures for minimizing gas wastage there. The other fields described are on a settled production basis and are declining at reasonably slow rates dependent to a large extent upon their age.

"TRANSMISSION FACILITIES.

"Comparison of gas production figures of the various fields, and the demand requirements of the several districts served, indicates that in eastern Los Angeles county ample transmission facilities are now installed. The transmission line from Brea to Pomona is becoming inadequate for meeting all the domestic winter load now placed upon it, however another line through Carbon Canyon is contemplated.

Further pipe line capacity from Long Beach to Los Angeles might well be installed if a sufficient industrial market can be obtained. It is most probable, however, that any investment in such a line would have to be amortized at a very high rate because of the expected short life of the field. Plans are now under way for materially increasing mixed gas deliveries from Los Angeles City to Sawtelle, and providing an ample supply to that point. The quantity of natural gas now piped to Los Angeles City for all purposes amounts to approximately 94,000 Mcf. per day, while a further net amount of about 56,000 Mcf. is delivered to Southern Counties Gas Company, making total daily deliveries to distributing companies of about 150,000 Mcf.

"NATURAL GAS REQUIREMENTS.

"Domestic gas operations in Los Angeles are mounting at a most rapid rate, with peak day gas sendouts growing in an ever increasing proportion. The increase in the number of domestic gas consumers on the system of the Los Angeles Gas Company and the city district of Southern California Gas Company amounted to about 40,000 during the year 1922, giving a total number of consumers of approximately 260,000 on January 1, 1923. A peak day sendout of 80,000 Mcf. of 750 B.t.u. gas by Los Angeles Gas and Electric Company was estimated for this past winter. However, this figure was exceeded with a sendout of 100,800 Mcf. of 700 B.t.u. gas. Southern Counties Gas Company is now serving about 85,000 consumers with gas from its own sources. This includes the San Bernardino district but excludes Santa Monica, the latter district receiving gas in wholesale from Southern California Gas Company. The estimated peak day domestic demand of Southern Counties Gas Company is 31,600 Mcf. The combined peak day domestic demand of all distributing companies was estimated at 144,900 Mcf. with total average daily deliveries of 126,000 Mcf. The distribution of the natural gas between companies and districts is not such, even if practical operating conditions would permit, that less than about 55,000 Mcf. to 60,000 Mcf. of artificial gas must be generated to meet domestic demands.

"ESTIMATED FUTURE GAS REQUIREMENTS AND PROBABLE SUPPLY.

"Reasonable conservative estimates of probable future gas supply available to distributing companies point to a total of about 160,000 Mcf. of natural gas in June, 1924, and probably 135,000 Mcf. a year later. It must be borne in mind that these estimates are based upon limited information and involve much variable and rather undependable data. Of the above figure it is believed that about 100,000 Mcf. per day of natural gas may be anticipated as available to Los Angeles City requirements in January, 1924, and 90,000 Mcf. in January, 1925. Estimated city peak day requirements for the same period amount to 81,000 Mcf. and 91,000 Mcf., respectively, for the maintenance of 750 B.t.u. standard.

"Investigation of probable immediate increases of natural gas available to Los Angeles city indicates the possibility of raising the present mixed gas standard from 750 B.t.u. to 825 to 850 B.t.u., which higher value it appears, with present information, could be maintained for a period of about two and a half years. Any such increase of gas quality will result in a proportionate reduction in quantity of gas sold and with present conditions of about equally low oil and gas prices, only a small economy would result from the use of more natural gas, so a higher rate would therefore be required in order to provide the utilities with the same rate of return as is now being earned.

"ADEQUACY OF GAS PLANT FACILITIES.

"A study of facilities in Los Angeles indicates that ample artificial gas generating equipment is now installed. Additional storage and compressor equipment is, however, needed to keep pace with the heavy growth of the district experienced this year. Plans for such work, together with very extensive enlargements of distribution lines are complete, and some of the work is in progress, notably the construction of two ten million foot gas holders. Additional natural gas transmission lines have been completed to the city and have thus added to the total gas available and to the security of the service."

Production and Value.

There is rather a wide variation in prices quoted for natural gas because such a large proportion is used directly in the field for driving gas engines and firing boilers, and is therefore not measured nor sold. Such companies as have attempted to place a valuation on the gas that was thus used in 1922 gave from 2¢–20¢ per 1000 cubic feet, at the well. From the totals shown in the tabulation following herein, the average value for all fields in 1922 works out at approximately 6.7¢. Approximately 7000 cubic feet of gas is equal to one barrel of oil in heating value, and is so accounted for by many operators. In driving gas engines, about 4000 cu. ft. per 24 hr. are consumed by a 25 h.p. engine, and 63,700 cu. ft. per day for heating a 70 h.p. steam boiler, which figures have been utilized in compiling this report, in those cases where gas was not metered.

NATURAL GAS, 1922.

County	M cu. ft.	Value
Fresno	1,694,090	$89,277
Kern	47,644,633	2,282,100
Kings	1,790	870
Los Angeles	23,254,549	1,653,571
Orange	25,269,402	2,096,629
San Joaquin	199,389	62,454
Santa Barbara	1,876,900	167,290
Tulare	380	190
Ventura	3,583,818	636,502
Butte, Humboldt, Lake, Mendocino, Sacramento, Sutter, Yuba*	103,076	101,147
Totals	103,628,027	$6,990,030

*Combined to conceal output of an individual producer in each.

The above totals for 1922 compare with 67,043,797 M. cu. ft. valued at $4,704,678 in 1921, being an increase of 55% in quantity, and of 49% in value. The Los Angeles County yield jumped from 6,944,277 M. cu. ft. to 23,254,549 M. cu. ft.; and Orange County from 14,097,639 M. cu. ft. to 25, 269, 402 M. cu. ft. Kern County, in spite of having a portion of her oil wells shut in, showed an increase of approximately 16% in natural gas yield. Small increases were registered by Santa Barbara and Ventura counties, and a slight decrease in the Coalinga field, Fresno County.

Natural Gas Production in California, Since 1888.

The production of natural gas in California by years since 1888 is given in the following table. The first economic use of natural gas in California was from the famous Court House well at Stockton, bored in 1854–1858. Beginning about 1883 and for several succeeding years, a number of gas wells were brought in around Stockton. Natural gas was known in a number of other localities, and occasionally utilized in a small way, notably at Kelseyville in Lake County, and in Humboldt County near Petrolia and Eureka, but there are no available authentic records of amounts or values previous to the year 1888. The most important developments in the commercial production of natural gas have been coincident with developments in the oil fields, by utilizing the casing-head gas as well as that from dry-gas wells.

Year	M cubic feet	Value	Year	M cubic feet	Value
1888	[a]12,000	$10,000	1906	168,175	$109,489
1889	[a]14,500	12,680	1907	169,991	114,759
1890	[a]41,250	33,000	1908	842,883	474,584
1891	[a]39,000	30,000	1909	1,148,467	616,932
1892	[a]75,000	55,000	1910	10,579,933	1,676,367
1893	[a]84,000	68,500	1911	[a]5,000,000	491,859
1894	[a] [b]85,080	79,072	1912	[a]12,600,000	940,076
1895	[a] [b]110,800	112,000	1913	14,210,836	1,053,292
1896	[a] [b]131,100	111,457	1914	16,529,963	1,049,470
1897	[a]71,300	62,657	1915	21,992,892	1,706,480
1898	[a]111,165	74,424	1916	28,134,365	2,871,751
1899	115,110	95,000	1917	44,343,020	2,964,922
1900	40,566	34,578	1918	46,373,052	3,289,524
1901	120,800	92,034	1919	52,173,503	4,041,217
1902	120,968	99,443	1920	58,567,772	3,898,286
1903	120,134	75,237	1921	67,043,797	4,704,678
1904	144,437	91,035	1922	103,628,027	6,990,030
1905	148,315	102,479			
			Totals	485,092,231	$38,232,312

[a]Quantity, in part, estimated, where values only were reported.
[b]Includes natural CO_2 from a mine in Santa Clara County.

Gasoline From Natural Gas.

More or less gas usually accompanies the petroleum in the oil fields, and such gas carries varying amounts of gasoline. More than 50 plants are in operation recovering gasoline by compression or absorption from this 'casing-head' gas. After the gasoline is extracted, the remaining 'dry gas' is taken into the pipe lines, by which it is distributed to consumers, both domestic and commercial.

In the Midway field, some of the casing-head gasoline is obtained as an incidental product to the compressing of the natural gas preliminary to transmission through the gas pipe lines. Some concerns market casing-head gasoline separately, while others turn it into the oil pipe lines, thus mixing this high-gravity gasoline with the crude oil for transportation to the refinery, where it is later regained. A total of 63,191,381 gallons of casing-head gasoline valued at $8,138,551 from all fields was reported by 55 operators, as made during 1922. This compares with 53,699,797 gallons by 47 operators in 1921. It was distributed by counties, as follows:

County	Gallons gasoline	Value
Fresno	642,749	$129,393
Kern	30,982,474	3,461,064
Los Angeles	3,206,217	579,193
Orange	16,934,026	2,090,102
Santa Barbara	7,613,164	1,150,263
Ventura	3,782,751	728,536
Totals	63,191,381	$8,138,551

The usual recoveries of gasoline from natural gas vary from one-half gal. to 3 gal. per 1000 cu. ft. of gas handled, the average being about 1 gal. per 1000 cu. ft.

PETROLEUM.

Bibliography: State Mineralogist Reports IV, VII, X, XII, XIII. Bulletins, 3, 11, 16, 19, 31, 32, 63, 69, 73, 82, 84, 89. Reports of Oil and Gas Supervisor 1915 to date (issued in monthly chapters since April, 1919). U. S. Geol. Surv., Bulletins, 213, 285, 309, 317, 321, 322, 340, 357, 398, 406, 431, 471, 541, 581, 603, 621, 623, 653, 691; Prof. Papers, 116, 117.

Petroleum is the chief fuel resource of California, and California led all other states of the Union in the number of barrels of crude oil produced in 1922. California, with Oklahoma, has enjoyed the distinction in recent years of standing at the head of the oil list on several occasions. California's oils are nearly all of asphalt base.

The crude oil production of California for 1922 amounted to a total of 138,468,222 barrels of clean oil, valued at $173,381,265 at the well. This total of quantity is compiled from the monthly production reports filed by the operators with the State Oil and Gas Supervisor, to which have been added figures for the output of a number of small operators in the Los Angeles city field not under the jurisdiction of the Supervisor, and from one property in Santa Clara County.

The question of the value of the crude oil yield, at the well, is a difficult one to settle with exactitude, principally because a large part of the output is not sold until after refining. The large refiners are also large producers of crude oil which they send direct from well to plant, hence much of the crude is not sold as such. The values used in the statistical reports of the State Mining Bureau since 1914 have been derived from averages of actual sales of crude oil of all grades in each field of the state, and these averages applied to the total yield of the respective fields. This we feel is a safer measure of commercial values than market quotations, because quotations do not always mean sales.

Features of 1922.

The outstanding features of the year 1922 in the oil industry of California were the enormous increases in Los Angeles and Orange counties due to new, gusher wells yielding high-gravity oil, and the consequent overproduction, necessitating the shutting-in of low-gravity wells in other fields of the state. This resulted in decreased output of crude oil in Fresno, Kern, and Santa Barbara counties. The upward leap of production in Los Angeles County (outside of the city field) due mainly to new wells at Long Beach and Santa Fe Springs was most remarkable, the first six months of 1922 showing a yield of 8,754,240 barrels, and the second six months 28,740,577 barrels. Orange County increased more than 8,000,000 barrels over its 1921 figure. Ventura County increased approximately 800,000 barrels. Decreases amounted to approximately 3,000,000 barrels in Fresno County and 4,000,000 barrels in Kern County.

There were two reductions in prices quoted for crude oil at the well, announced by the marketing companies in July, 1922, and a further reduction posted January 6, 1923. These reductions have only to a limited extent affected the production total by causing the shutting-in of wells yielding oil of the lower specific gravities and in the districts outside of the areas where intensive campaigns of new developments are taking place. The unprecedented increase in production has taxed the storage, transportation, and refining facilities of all of the marketing concerns. Shipments by sea via the Panama Canal to Atlantic seaboard points has been of vital assistance.

According to Collom,[1] in December:

"Consumption has been greatly increased by shipments of crude and fuel oil to the Atlantic Coast via the Panama Canal. Existing differentials in prices and transportation costs between California crudes and the so-called Mexican light crude are enabling California marketers to ship oil in quantities estimated as high as 50,000 barrels daily. This condition has created a new outlet for California petroleum.

"California production still leads consumption by about 2,000,000 barrels monthly. In addition it is estimated that 2000 wells, with a normal output of about 72,000, are shut down. A large part of the oil shut-in is heavy grade, less than 20 deg. Baume. Oil in storage at the end of December, 1922, was about 1,000,000 barrels in excess of the storage of May, 1915, the previous high point for stored oil. Production at the close of 1922, not including potential production shut-in, was 170,000 barrels in excess of the average production increase over the period 1911 to 1921, inclusive, and consumption was 35,000 barrels in excess of the average consumption increase over the same period.

"Drilling was concentrated in the Huntington Beach, Long Beach and Santa Fe Springs oil fields during 1922 and greatly curtailed in the other fields, especially in the San Joaquin Valley. Very few wells are being drilled in the oil fields of Fresno, Santa Barbara and Ventura counties. On the whole, however, more new wells were reported to the State Oil and Gas Supervisor in 1922 than in 1921. 1439 new wells were reported in 1922 and 1287 new wells in 1921. 799 new wells, 55% of the drilling of the State, were reported in the three new fields; Huntington Beach, 193 wells, Long Beach 348 wells, and Santa Fe Springs, 258 wells.

[1] Collom, R. E., Weekly press bulletin, No. 375: Dept. of Petroleum and Gas; Cal. State Min. Bur., Dec. 30, 1922.

"The present situation of overproduction in California is due primarily to the competitive drilling of offset wells on or adjoining small property holdings. In the development of each of the three new fields town-lot drilling has played a predominating part. Town-lot drilling should not be confused with close drilling or small acreages per well. The spacing of wells in several California fields, such as Kern River and McKittrick, are on an average basis of 2.0 to 2.4 acres per well. In these fields however, are ten, twenty and forty acre tracts, or larger, in which wells were spaced according to what the operator considered was the most economical plan for extracting the oil.

"In town-lot drilling every well is in a sense an offset well. The size and shape of the property controls the spacing of offset wells. They may be only 50 feet apart. Offset wells are not drilled so much for the purpose of developing and producing that oil to which each operator has an unhindered right, within his own property lines, as to get the oil lying under each side of the boundary line, which will move to the well first drilled into the oil sand. This condition is one of the recognized fundamentals of oil field development, and where properties are leased, the leases carefully safeguard each lessor's interest as opposed to the adjoining lessor. The necessities of drilling offset wells, to meet lease requirements, is therefore, one of the greatest contributory factors to forced drilling where small property ownerships are involved.

"Intensive offset drilling necessitates abandonment of the principle of leaving certain quantities of recoverable oil in its underground storage until the maximum profit can be obtained, and then bringing the oil to the surface by drilling the wells according to established oil field practice, as to spacing and careful drilling methods. Wells are raced to production and each new producing well calls for a number of offsets.

"In the town-lot oil fields wells have been drilled as close as three to an acre. Town-lot drilling brings rapid recovery of flush production. For the industry as a whole it means serious overproduction. For the operator drilling in congested areas there is not enough oil underground to yield a profit for all against the cost of each well, the productive unit.

"The rate of production of California petroleum has its high and low points, like every other oil producing district, in the inexorable workings of the law of supply and demand. It would seem possible, however, by careful study of development problems and intelligent effort, to level off some of the extremely high and low points in the curve. Sometimes, when oil is badly needed, as in the war period, operators do not know where to get it, or how best to get the maximum output with minimum use of money, men and materials. In the present condition much oil is available but it is being produced like a big gusher out of control, because there is not the proper economic machinery to regulate the flow.

"It is possible that some of the economic evils of town-lot drilling could be eliminated by carefully considered legislation. Such legislation should recognize the equitable right of every property owner in the oil under his land, whether a small lot or ten acres, and should rigorously prevent the exploitation of California's most valuable mineral resource by the stock jobbers and 'uniteers.'"

One of the outstanding features of the production record for the year 1922, is that, although the oil production of Los Angeles and Orange counties increased from 35,645,081 barrels of oil in 1921 to 68,544,308 barrels in 1922, an increase of 95%, the water production only increased 5.6%. To anyone familiar with the complex subsurface conditions as to stratigraphic relationship of oil and water in the three new fields, which have been so rapidly developed, this is evidence of the value and effectiveness of the work of supervision by this bureau's department of petroleum and gas.

Outlook for 1923.

The outlook for the current year is that the figures of crude oil yield of the previous year will be exceeded. At present writing (July 2), the peak has not yet been reached. However, notices filed with the State Oil and Gas Supervisor during the week ending June 16, 1923, showed a marked decrease in the number of new wells reported ready to drill, in fact the least number so reported since November, 1921, the decrease being especially noticeable for Santa Fe Springs, Long Beach, and Huntington Beach fields; but it will be some time before this decrease in the number of wells being drilled will reflect corresponding decreases in production. For example, it takes about 75 days to drill a well to completion in the Meyer sand at Santa Fe Springs and therefore the wells now drilling, and not those just starting, must be considered to get an idea of the activities of the next three months during which time a large proportion of the wells now drilling will be completed.

Relative to the situation in that section, the State Oil and Gas Supervisor has written the following.[2]

"The continuous intensive drilling of the Huntington Beach, Long Beach and Santa Fe Springs oil fields of southern California has brought oil production to the saturation point. Almost a half million barrels of crude oil is flowing daily from the three southern fields. Since frenzied town-lot development started in the early part of 1921, there has been only one way of preventing such an outcome—to curtail drilling. The complicated interests of lessors, royalty holders, drilling contractors and town-lot operators, seem to have made accomplishment of a concerted effort in this direction impossible. A forced reduction in drilling and production through the inexorable workings of the law of supply and demand appears to be the only remedy.

"Four reductions in the value of the crude product within a year have caused no appreciable check in drilling. Over 500 wells are now drilling in the three fields. A recent movement to restrict the output of individual wells will further curtail the profits derivable from each producing unit. The over-supply is being more actively maintained by initial productions of wells just completed than the rapidly declining old wells. Initial production of 12 wells recently completed at Santa Fe Springs averaged 3950 barrels per well as compared with an average daily production of 1600 barrels per well for all producing wells in the field.

"It should be borne in mind—in this town-lot development—that an appreciable amount of drilling has been financed by people not experienced in the oil industry. They have invested in things hoped for rather than seen. Probably such drilling will continue regardless of the profit that can be realized from the product. It is estimated that $58,000,000 has been expended in drilling alone since these fields started. The three fields have produced approximately 90,700,000 barrels from January 1, 1921, to May 1, 1923.

"At the beginning of 1921 there were 43 producers of petroleum in Los Angeles and Orange counties. In January, 1923, the number of producers had increased to 175.

"There has been no material change in the number of marketing concerns. Five of the large marketing companies of California are confronted with the huge task of taking care of a major portion of the production, providing transportation, storage, and refining facilities, for a greater additional quantity of crude oil than these same companies handled throughout the entire plant of the industry at the beginning of 1921.

"Marketers can not receive oil or provide storage for it beyond the conservative limits of their financial resources or responsibility. The cost of building steel storage alone is 55 to 60 cents per barrel of capacity. The Santa Fe Springs oil field can fill five 55,000 barrel tanks in one day.

"Some of the factors of the present situation as affecting the public are these:

"The laws of supply and demand and the natural competition in the industry has given the public the benefit of exceptionally low prices of gasoline. Gasoline in California is now retailing for the lowest price it has reached in seven years. But the factor that is forcing a reduction in the price of gasoline, namely, overproduction of refinable crudes, is drawing in a wasteful way on reserves of crude oil and natural gas which properly should be conserved for the future. The necessity of giving the maximum accommodation in transportation, storage, and refinery facilities, for the refinable crudes of southern California has forced a marked curtailment in production and transportation of low-grade crudes in other fields, the principal source of California's fuel oil."

Production Figures.

The following table gives the production and value by counties for 1922 compared with the 1921 figures:

TABLE A.

Production and Value of Oil, by Counties.

	1921		1922	
	Barrels	Value	Barrels	Value
Fresno	12,161,565	$18,643,679	9,265,526	$9,895,582
Kern	57,434,945	97,639,407	53,512,157	64,803,222
Los Angeles	12,395,605	25,795,254	37,726,367	52,930,093
Orange	22,929,466	45,995,509	31,049,491	36,483,162
San Luis Obispo	30,725	43,691	33,856	31,892
Santa Barbara	5,465,942	9,122,657	3,931,155	3,974,398
Ventura	2,167,326	5,869,119	2,933,685	5,236,628
San Mateo and Santa Clara*	14,286	27,909	15,985	26,288
Totals	112,599,860	$203,138,225	[a]138,468,222	$173,381,265

*Combined to conceal output of a single operator in San Mateo County.

[a]See p. 24, *ante*.

[2]Collom, R. E., Weekly press bulletin, No. 393; Dept. of Petr. and Gas, Cal. State Mg. Bur., May 5, 1923.

TABLE B.

Average Price of Oil per Barrel, by Counties, 1915-1922.

County	1915	1916	1917	1918	1919	1920	1921	1922
Fresno	$0.452	$0.515	$0.516	$0.825	$1.191	$1.293	$1.483	$1.068
Kern	.409	.423	.641	.893	1.252	1.350	1.714	1.211
Los Angeles	.550	.629	.651	1.176	1.340	1.380	1.532	1.403
Orange	.675	.512	.663	1.003	1.412	1.860	2.138	1.175
San Luis Obispo	--------	--------	.450	.926	.905	1.040	1.400	0.942
Santa Barbara	.460	.611	.794	.808	1.235	1.125	1.575	1.011
Santa Clara	.530	.666	.663	1.387	1.700	1.600	1.485	1.616
Ventura	1.050	.855	1.045	1.318	1.480	1.635	2.507	1.785
State average	$0.461	$0.479	$0.636	$0.908	$1.278	$1.409	$1.726	$1.249

The low price in Santa Barbara County for 1919 and 1920 was due to a large production of 8° to 10° gravity oil from the Casmalia field, which brought only about 50¢ per barrel in 1919 and 39¢ in 1920. For several years previous to 1919, the state average value per barrel at the well for crude oil as determined by the statistical returns was noted to practically coincide with the quotations during the same years for 23° gravity oil. In 1919, the average value for all grades worked out at a figure corresponding to the quotations for 28° oil, due to the fact that the increased output of that year was mainly from the Montebello field in Los Angeles County which yielded high-gravity oil. The 1920 figure of $1.726 corresponds approximately to the average of quotations for 24°-25° oil for the year; the 1921 figure of $1.804, to 26° quotations; and the 1922 figure of $1.249, to 27° quotations.

TOTAL PETROLEUM PRODUCTION OF CALIFORNIA.

The presence of oil seepages and springs in Los Angeles and Ventura counties was known and even utilized in a small way early in the history of California. According to Hanks,[3] in 1874 production amounted to 36 bbl. per day from natural flows in Pico Cañon (Newhall), and at Sulphur Mountain (Ventura County), the oil being of 32° gravity average.

[4]"Work was commenced in Pico Cañon in 1875, by drilling three shallow wells with spring pole, all of which yielded oil at depths of from 90 to 250 feet. Actual work of development commenced with steam machinery in 1877."

In 1877. Pico averaged 40-50 bbl. daily, and Ventura, 80 bbl. daily. In 1878, there was some production (@ 60 bbl. per day, for a time) from wells in Moody Gulch, near Los Gatos, Santa Clara County, the oil being of 46° Baumé.

The first wells in the Coalinga, Fresno County, and Summerland, Santa Barbara County, fields were drilled in 1890, but Coalinga did not make its influence felt conspicuously on the state's annual output until 1903. The Summerland yield never has been large, The Salt Lake field near Los Angeles began production in 1894 and in 1897 reached over a million barrels annually.

In the Kern County fields, the first well was drilled in Sunset in 1891, Midway in 1900, McKittrick in 1892, Kern River in 1899. The

[3]Hanks, Henry G., Report IV of State Mineralogist, p. 298, 1884.
[4]*Idem*, p. 301.

Sunset-Midway district attained a yield of over 4,000,000 bbl. in 1909, and over 20,000,000 bbl. in 1910. Kern River field produced over 3,000,000 bbl. in 1901.

The first well in the Santa Maria-Lompoc group, Santa Barbara County, was drilled in 1901, and the district advanced to a yield of over 3,000,000 bbl. annually in 1905.

The Whittier-Fullerton field in Los Angeles and Orange counties became an important factor in 1902. The Montebello field, Los Angeles County, was the conspicuous addition in 1918-1919; and Elk Hills, Kern County, with Huntington Beach and Richfield, Orange County, in 1920. In 1921, the new fields added were Long Beach and Santa Fe Springs, Los Angeles County. In 1922, Torrance field in Los Angeles County, and Wheeler Ridge field in Kern County were added.

The effect of the advent of these various fields to the producing column will be noted in the tabulation herewith, by years:

TABLE C.

Total Petroleum Production in California.

Year	Barrels	Value	Year	Barrels	Value
To and inc. 1875	[a]175,000	[b]$472,500	1900	4,329,950	$4,152,928
1876	12,000	30,000	1901	7,710,315	2,961,102
1877	13,000	29,250	1902	14,356,910	4,692,189
1878	15,227	30,454	1903	24,340,839	7,313,271
1879	19,858	39,716	1904	29,736,003	8,317,809
1880	40,552	60,828	1905	34,275,701	9,007,820
1881	99,862	124,828	1906	32,624,000	9,238,020
1882	128,636	257,272	1907	40,311,171	16,783,943
1883	142,857	285,714	1908	48,306,910	26,566,181
1884	262,000	655,000	1909	58,191,723	32,398,187
1885	325,000	750,750	1910	77,697,568	37,689,542
1886	[a]377,145	[b]870,205	1911	84,648,157	40,552,088
1887	678,572	1,357,144	1912	89,689,250	41,868,344
1888	690,333	1,380,666	1913	98,494,532	48,578,014
1889	303,220	368,048	1914	102,881,907	47,487,109
1890	307,360	384,200	1915	91,146,620	43,503,837
1891	323,600	401,264	1916	90,262,557	57,421,334
1892	385,049	561,333	1917	95,396,309	86,976,209
1893	470,179	608,092	1918	99,731,177	127,459,221
1894	783,078	1,064,521	1919	101,182,962	142,610,563
1895	1,245,339	1,000,235	1920	103,377,361	178,394,937
1896	1,257,780	1,180,793	1921	112,599,860	203,138,225
1897	1,911,569	1,918,269	1922	138,468,222	173,381,265
1898	2,249,088	2,376,420			
1899	2,677,875	2,660,793	Totals	1,591,654,183	$1,369,360,439

[a]U. S. G. S., Min. Res. of U. S., 1886, p. 440, for quantities to and including 1886.
[b]Values have been estimated for the years to and including 1886, after consulting a number of contemporaneous publications, including the Mining & Scientific Press, Reports of the State Mineralogist, and U. S. Reports. The figures for 1887 to date are from records of the State Mining Bureau.

Well Data.

The following table is compiled from the monthly statements contained in the Standard Oil Bulletin:

TABLE D.

Well Operations, by Fields, 1922.

	Producing Dec., 1921	Producing Dec., 1922	Completed during year	Abandoned during year	Bbl. per well produced per day Dec., 1922
Kern River	2,207	2,159	24	6	9.1
McKittrick	350	283	4	5	23.0
Midway-Sunset	2,707	2,156	230	28	35.5
Elk Hills*	----------	88	24	2	311.2
Lost Hills-Belridge	612	417	4	2	16.0
Coalinga	1,176	679	12	11	20.6
Santa Maria-Lompoc	416	322	3	8	25.3
Ventura-Newhall	526	557	34	11	18.8
Los Angeles-Salt Lake	671	669	6	1	5.0
Whittier-Fullerton	1,116	551	70	3	22.4
Coyote*	----------	234	3	2	75.9
Santa Fe Springs*	----------	70	70	9	1,280.0
Montebello*	----------	116	8	1	160.0
Richfield*	----------	169	18	7	115.0
Huntington-Newport	51	153	222	7	413.0
Long Beach*	----------	137	93	11	785.0
Torrance-Redondo*	----------	13	11	----------	168.0
Summerland	137	135	----------	----------	1.1
Watsonville	9	8	----------	----------	7.5
Totals	9,978	8,916	836	144	[a]55.8

*Segregated records beginning Aug., 1922.
[a]State average.

Specific Gravities of Oils Produced.

The proportion of heavy and light oil produced in the various fields is shown in Table E, following, for which we are indebted to the Standard Oil Company. Under present practice, oil below 18° Baumé may be considered as largely refinable for fuel oil and lubricants, while the lighter oils yield varying amounts of the higher refined products with corresponding proportions of residuum and fuel oil. Specific gravities in California range from 8° Baumé in the Casmalia field, Santa Barbara County, to 56° Baumé in Ventura County.

California crude oils are all essentially of asphalt base, with a few notable exceptions. In the following localities are wells yielding crudes containing both asphalt and paraffine constituents: Oil City field, Coalinga; a few deep wells in East Side field, Coalinga; a considerable part of the Ventura County fields; Western Minerals area, south of Maricopa; Wheeler Ridge, Kern County.

TABLE E.

Production of Light and Heavy Oil, by Fields, 1922.

Field	Under 18° (barrels)	18° and over (barrels)	Total (barrels)
Kern River	7,323,869		7,323,869
McKittrick	2,383,169		2,383,169
Midway-Sunset	10,779,392	30,926,486	41,705,878
Lost Hills and Belridge	693,160	2,150,087	2,843,247
Wheeler Ridge		500	500
Coalinga	4,045,462	5,092,959	9,138,421
Santa Maria-Lompoc	1,872,119	2,023,123	3,895,242
Ventura County-Newhall	118,792	2,930,087	3,048,879
Los Angeles-Salt Lake	1,177,926	126,335	1,304,261
Whittier-Fullerton	1,057,314	26,262,925	27,320,239
Santa Fe Springs		10,976,873	10,976,873
Huntington Beach	531,325	10,670,462	11,201,787
Signal Hill	35,005	18,213,262	18,248,267
Torrance-Redondo	30,831	152,740	183,571
Summerland	54,005		54,005
Watsonville	23,725		23,725
Totals	30,126,094	109,525,839	139,651,933

In the September 1922 issue of 'Mining in California'[5] was published a chart which reveals the fact that a decided change has taken place in the relative proportions of light and heavy crudes produced in California since 1910, taking 18° Baumé as the dividing line.

A marked drop took place in the low-gravity yield from 1910 to and including 1914. From 1914, it has remained almost stationary, with a slight drop in 1921, while the high-gravity yield has increased at a rapid rate since 1915. The proportions have been reversed from approximately 75% low—25% high in 1914 to 25% low—75% high in 1921. This has been an important factor in its effect upon the average price per barrel of the state's output in these years. Its effect upon the relative situation between production and consumption has also been important. It has been a fortunate development, in view of the increased demand for refinery products (gasoline, in particular), and the lessened demand for fuel oil the past three years owing in part to the shutting down of the western copper smelters which were large consumers of California fuel oil.

The beginning of 1921 was marked by the discontinuance of drawing on storage, owing to the current production of crude oil overbalancing consumption. This still continues, so that on December 31, 1922, the stock on hand amounted to 61,184,928 barrels,[6] an increase of 26,163,016 barrels over the 35,021,912 barrels on hand December 31, 1921.

Operating Data.

The following tabulation (Table F) is compiled from data published by the Department of Petroleum and Gas,[7] semiannually, and here combined to show the entire year's operations for all the fields. The 'districts' are the geographical subdivisions as administered by the Department, and which are outlined on the accompanying map.

[5]Report XVIII of State Mineralogist, p. 442, 1922.
[6]Standard Oil Bulletin, February, 1923.
[7]Eighth Annual Report: Monthly summary of operations, Aug., 1922, p. 20; Feb., 1923, pp. 6-7.

The column designated 'potential' was inserted to show the potential number of wells in the areas affected by the shutting-in due to overproduction, as compared with the number actually producing during that period.

It will be noted that the state average yield of oil per well per day was 38.8 barrels for the first six months and 52.8 barrels for the second. This compares closely with the figure of 55.8 barrels average for December derived from Standard Oil Company data and shown in Table D, on a preceding page.

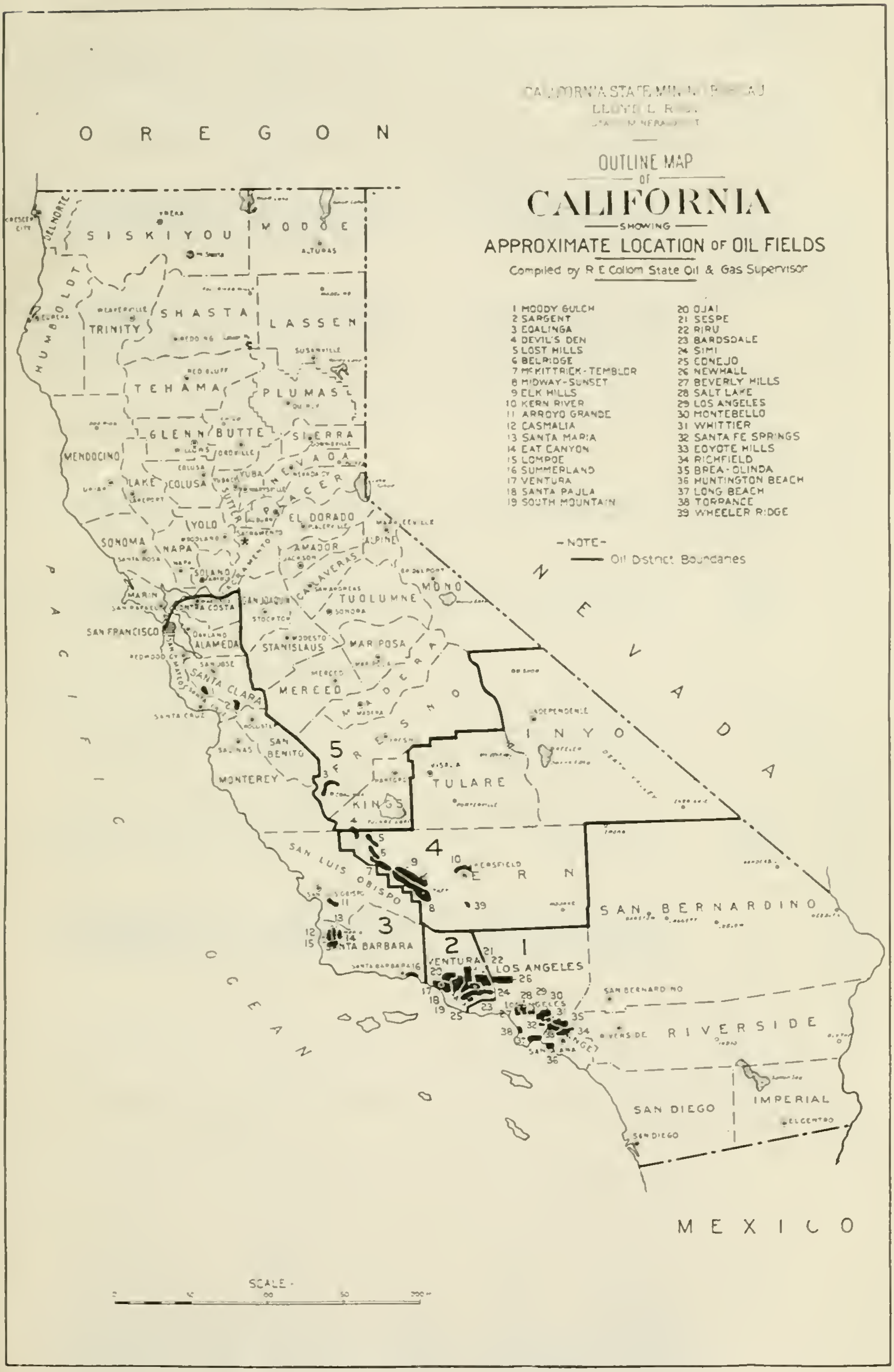
OUTLINE MAP
OF
CALIFORNIA
SHOWING
APPROXIMATE LOCATION OF OIL FIELDS
Compiled by R E Collom State Oil & Gas Supervisor
1 MOODY GULCH
2 SARGENT
3 COALINGA
4 DEVIL'S DEN
5 LOST HILLS
6 BELRIDGE
7 McKITTRICK-TEMBLOR
8 MIDWAY-SUNSET
9 ELK HILLS
10 KERN RIVER
11 ARROYO GRANDE
12 CASMALIA
13 SANTA MARIA
14 CAT CANYON
15 LOMPOC
16 SUMMERLAND
17 VENTURA
18 SANTA PAULA
19 SOUTH MOUNTAIN
20 OJAI
21 SESPE
22 PIRU
23 BARDSDALE
24 SIMI
25 CONEJO
26 NEWHALL
27 BEVERLY HILLS
28 SALT LAKE
29 LOS ANGELES
30 MONTEBELLO
31 WHITTIER
32 SANTA FE SPRINGS
33 COYOTE HILLS
34 RICHFIELD
35 BREA-OLINDA
36 HUNTINGTON BEACH
37 LONG BEACH
38 TORRANCE
39 WHEELER RIDGE
- NOTE -
Oil District Boundaries
O R E G O N
N E V A D A
P A C I F I C
O C E A N
M E X I C O
SISKIYOU
MODOC
SHASTA
LASSEN
TRINITY
TEHAMA
PLUMAS
GLENN
BUTTE
SIERRA
MENDOCINO
LAKE
COLUSA
YOLO
EL DORADO
SONOMA
NAPA
AMADOR
ALPINE
SOLANO
MARIN
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
MONO
SAN FRANCISCO
ALAMEDA
STANISLAUS
MARIPOSA
MERCED
SANTA CLARA
SAN BENITO
MONTEREY
INYO
TULARE
KINGS
KERN
SAN LUIS OBISPO
SANTA BARBARA
VENTURA
LOS ANGELES
SAN BERNARDINO
RIVERSIDE
SAN DIEGO
IMPERIAL
SCALE

TABLE F. PRODUCTION AND OPERATING DATA OF CALIFORNIA OIL FIELDS—1922.

Field	January 1 to June 30. Average number of producing wells		Oil (bbl.)	Number of days producing	Production per well per day (bbl.)		Percentage of time wells produced	July 1 to December 31. Average number of producing wells		Oil (bbl.)	Number of days producing	Production per well per day (bbl.)		Percentage of time wells produced
	Actual	[a]Potential			Oil	Water		Actual	[a]Potential			Oil	Water	
District No. 1:														
Beverly Hills	15	----------	82,586	2,423	34.1	38.9	89.2	15	15	92,636	2,418	38.3	52.9	87.6
Brea-Olinda	399	----------	2,612,527	72,017	36.3	9.0	99.7	354	396	1,804,528	59,866	30.1	8.2	91.9
Coyote Hills	228	----------	3,628,028	39,519	91.8	26.4	95.8	230	230	3,514,831	40,598	86.6	26.7	95.9
Huntington Beach	109	----------	3,804,483	13,779	276.1	7.1	69.8	160	160	7,375,399	22,360	329.8	7.5	76.0
Long Beach	40	----------	2,671,036	3,554	751.6	10.9	49.1	144	144	15,378,204	17,343	886.7	6.5	65.5
Montebello	141	----------	3,723,299	25,460	146.2	28.4	99.8	139	143	2,891,362	23,487	123.1	28.4	91.8
Newhall	74	----------	41,170	13,297	3.1	8.3	99.3	62	73	34,661	10,853	3.2	5.0	95.1
Richfield	125	----------	4,419,320	21,735	203.3	5.9	96.1	165	165	3,890,375	27,706	140.4	7.8	91.3
Salt Lake	256	----------	420,946	41,964	10.0	8.0	90.6	254	254	408,552	43,762	9.3	9.5	93.6
Santa Fe Springs	10	----------	1,274,676	639	1,994.8	19.6	3.5	74	74	9,355,754	7,882	1,187.0	10.0	57.9
Torrance[b]	2	----------	13,126	64	205.1	--------	17.6	10	10	177,245	911	194.6	1.2	49.5
Whittier	170	----------	527,401	26,556	19.9	21.6	86.3	169	169	402,160	27,095	14.8	19.8	87.1
Totals	1,569	----------	23,218,598	261,007	88.96	14.7	91.9	1,776	1,833	45,325,710	284,281	159.4	13.9	87.0
District No. 2:														
Bardsdale	139	----------	202,531	24,208	8.3	1.2	96.0	139	139	210,342	24,171	8.7	1.3	94.0
Conejo	16	----------	2,550	2,406	1.1	2.7	83.0	18	18	635	3,312	0.2	0.1	100.0
Ojai	60	----------	39,676	10,319	3.8	2.5	95.0	63	63	40,697	10,134	4.0	1.8	87.0
Piru	80	----------	58,020	13,409	4.3	6.2	92.0	83	86	58,677	14,338	4.1	11.2	90.0
Santa Paula	50	----------	17,272	8,231	2.1	0.8	91.0	52	52	19,125	8,967	2.1	0.7	93.0
Sespe	26	----------	25,777	4,345	5.9	8.0	92.0	30	30	27,059	4,887	5.5	0.6	94.0
Simi	54	----------	45,691	8,856	5.1	1.4	91.0	55	55	41,020	8,561	4.8	1.5	84.0
South Mountain	35	----------	691,313	5,899	117.1	.001	93.0	39	39	740,257	6,458	114.6	0.2	99.0
Ventura	19	----------	191,719	3,130	61.2	76.6	91.0	27	27	521,318	4,192	124.3	73.3	84.0
Totals	480	----------	1,274,555	80,806	15.7	5.1	96.0	509	509	1,659,130	85,023	19.5	6.4	91.0
District No. 3:														
Arroyo Grande	19	----------	17,884	2,570	6.9	9.9	75.0	19	19	16,012	2,618	6.0	8.2	75.6
Casmalia	92	----------	657,895	15,453	42.6	191.2	93.0	91	91	634,534	15,892	39.9	207.0	91.8
Cat Canyon	40	----------	357,805	6,637	53.6	12.3	92.0	32	44	255,516	4,517	56.6	9.1	76.7
Half Moon Bay*	2	----------	461	360	1.2	--------	50.0	4	4	367	215	1.1	0.0	33.3
Lompoc	24	----------	199,531	3,338	59.8	82.7	77.0	6	27	38,452	768	50.1	10.0	69.6
Santa Maria	223	----------	1,055,091	32,755	32.2	34.6	81.0	156	234	681,938	23,318	29.2	35.9	81.2
Sargent	7	----------	7,400	1,267	5.7	--------	98.0	9	9	7,575	1,514	5.0	0.0	91.4
Summerland*	135	----------	25,275	22,753	1.1	12.7	93.0	133	133	25,088	22,314	1.1	12.5	91.2
Totals	542	----------	2,321,302	85,164	27.2	56.0	87.0	453	561	1,659,512	71,216	23.3	63.0	85.4

District No. 4:														
Belridge-Lost Hills	516	597	1,573,092	85,513	18.4	17.6	91.6	417	611	1,268,737	71,257	17.8	18.7	92.9
Elk Hills	153	168	6,621,946	23,867	277.4	3.7	86.2	117	201	4,982,368	17,621	282.7	2.6	81.8
Kern River	2,146	2,240	3,516,933	364,709	9.6	48.7	93.9	2,163	2,239	3,575,964	378,452	9.4	48.9	95.1
McKittrick-Temblor	308	313	1,191,652	49,382	24.1	67.7	88.6	294	313	1,149,378	49,269	23.3	69.0	91.1
Midway-Sunset	2,542	2,692	15,068,106	424,048	35.5	21.4	92.2	2,296	2,809	14,563,981	381,378	38.2	21.3	90.3
Totals	5,665	6,010	27,971,729	947,519	29.5	33.5	92.4	5,287	6,173	25,540,428	897,977	28.4	35.0	92.3
District No. 5:														
Coalinga	1,219	1,359	6,110,207	194,542	31.41	11.23	88.17	763	1,362	3,155,319	125,817	25.1	14.2	89.6
Grand totals	9,475	----------	60,896,391	1,569,068	38.8	27.4	91.5	8,788	10,441	77,340,099	1,464,314	52.8	28.8	90.6

*Estimated. [a]Includes wells capable of producing which were shut down on account of overproduction. [b]Heretofore known as Redondo field.

Financial and Operating Conditions of California Oil Fields, 1922.

Financial results of the oil business during 1922 are shown by the following table. The features worthy of mention are: (1) the lower price received for the year as shown by the state average of all grades. (2) a slight increase in the total amount of dividends paid. (3) increases in the number of barrels per well per day yield (see Table I), for all 'fields' except Kern River and Santa Barbara County. (4) somewhat lower operating costs in most fields.

With reference to Table I, it should be noted that although it lacks data from the larger operators who have refineries and with interests in more than one field, yet the data given are of economic value and interest in that they indicate the conditions prevailing among the smaller companies and operators.

Operating cost per well is not always lower for the dividend companies than others. Profitable operations seem to depend generally upon large wells, high-grade oil, and proximity to market. Price and profits have usually been greater in the Los Angeles-Orange-Ventura fields than in others, doubtless largely due to the proximity to market and higher grades of oil. Crude oil testing as high as 56° Baumé is obtained from some of the Ventura wells.

TABLE G. CAPITALIZATION.

Field	Number of companies considered*	Per cent of total product of field	Capital	
			Cash	Property
Fresno County—Coalinga	66	35	$2,701,943	$8,901,709
Kern County:				
Kern River	62	27	7,901,539	5,149,172
Midway	86	26	6,053,127	18,258,543
Sunset-Maricopa	52		2,909,571	11,754,071
McKittrick, Lost Hills, Belridge, Devils Den, Elk Hills	58	90	3,341,930	10,242,671
Los Angeles County	121	14	11,971,983	18,058,516
Orange County	59	25	9,883,623	12,864,397
Santa Barbara County	22	26	1,830,641	5,246,926
Ventura County	45	64	2,255,545	9,739,307
Subtotals	571		$48,849,932	$100,215,312
Miscellaneous and marketing companies[1]	98	61	332,255,504	108,721,021
Totals	669		$381,105,436	$208,946,333

*See Table I, following.

[1]Includes companies having refineries, and those operating in several fields whose data could not be segregated as to counties or fields.

TABLE H. Dividends Paid by Oil Companies, 1917–1922.

Field	1917		1918		1919		1920		1921		1922	
	Companies	Value	Companies	Value	Companies	Value	Companies	Value	Companies	Value	Companies	Value
Coalinga	20	$712,331	23	$1,055,600	24	$1,352,969	29	$1,297,694	21	$1,142,767	20	$893,210
Kern River	22	306,508	31	609,293	27	1,235,877	26	783,625	28	390,791	20	591,306
Midway	34	1,938,769	42	3,015,862	32	8,360,417	39	7,096,819	34	4,311,539	30	2,709,985
Sunset and Maricopa	14	682,614	15	638,926	15	595,535	14	691,611	18	960,459	19	936,174
McKittrick, Belridge, Lost Hills, Devils Den, Elk Hills	14	837,129	12	708,984	9	548,224	12	1,231,045	13	2,603,490	10	733,460
Santa Barbara County	6	923,228	5	286,768	5	355,490	7	312,332	5	400,535	5	317,014
Ventura County	3	71,637	2	4,400	4	120,584	5	559,942	6	1,362,210	7	1,204,631
Los Angeles County } Orange County	16	3,079,447	14	1,201,021	17	2,373,403	20	3,282,497				
Los Angeles County									11	562,224	16	1,442,470
Orange County									11	1,395,158	8	331,345
Subtotals	129	$8,551,693	144	$7,520,854	133	$14,912,529	152	$15,255,565	150	$13,129,176	135	$9,159,595
Miscellaneous and marketing companies[1]	12	*40,981,214	11	19,984,138	26	20,476,322	9	31,072,321	11	35,886,119	10	41,030,594
Totals	141	$49,532,907	155	$27,504,992	159	$35,418,851	161	$46,327,886	161	$49,015,295	145	$50,190,189

*Includes a 33⅓ per cent stock dividend of the Standard Oil Company. [1]See Table G, preceding.

TABLE I. Average Prices of Light and Heavy Oils, and Operating Data, 1922.

Field	Price				Operating data					
					All companies considered*			Dividend companies‡		
	Under 18° Baume	18° and over	Average price	Price to dividend companies	Barrels per well per day yield	Operating cost per well day	Operating cost per barrel	Barrels per well per day yield	Operating cost per well day	Operating cost per barrel
Coalinga	$0.896	$1.224	$1.068	$1.008	20.3	$12.27	$0.605	20.5	$13.30	$0.649
Kern River	0.885	----------	1.211	0.882	8.0	2.84	0.353	6.9	2.09	0.304
Midway	1.008	1.558	1.401	1.479	41.8	15.68	0.375	48.1	1.73	0.360
Sunset and Maricopa	0.985	1.457	1.143	1.098	29.8	12.52	0.420	32.7	11.60	0.355
McKittrick, Lost Hills, Belridge, Devils Den, Elk Hills	0.986	1.242	1.123	1.123	22.1	9.14	0.413	26.7	7.16	0.268
Los Angeles County	0.906	1.427	1.403	1.584	38.7	41.29	1.067	28.4	39.47	1.393
Orange County	0.890	1.203	1.175	1.212	101.4	41.34	0.396	121.1	48.20	0.398
Santa Barbara County	0.664	1.661	1.011	1.425	23.6	11.60	0.492	20.5	11.42	0.557
Ventura County	1.003	1.793	1.785	1.193	20.5	13.74	0.672	15.3	9.21	0.603

*See Table G, preceding. Does not include companies with refineries, nor those operating in several fields whose data could not be segregated as to counties or fields. The data given are of value, however, as showing the conditions obtaining among the smaller operators.

‡See Table H, preceding.

It should be noted that in the case of a county like Ventura, with only a few producers, the averages are not so significant as in other fields with a large number of operators. The figures of a single large operator in such a case can materially affect the general average if they should be much above or below the average of the others.

Proved Oil Land.

The area of proved oil land increased during 1922 to a total of 112,761 acres compared with 109.214 acres in 1921. Kern, Los Angeles, and Orange counties were the important contributors to the increase. Of this total, 17.322 acres being owned by federal, state, and city governments is not assessable for the support of the Department of Petroleum and Gas of the State Mining Bureau. The acreage in 1922 was distributed by counties as follows:

TABLE J. Proved Oil Land.

County	Land (acres)	Wells (No.)
Fresno	14,654	1,028
Kern	68,976	5,632
Los Angeles	7,469	1,451
Orange	7,597	856
San Luis Obispo	772	17
Santa Barbara	9,303	367
Santa Clara	80	10
Ventura	3,910	529
Totals	112,761	9,890

The Department's method of classifying proved oil land has been described by Collom.[8]

"The proved oil and gas areas in the State of California are determined and mapped each year by the engineering staff of the Department of Petroleum and Gas under the direction of the supervisor. The purpose is to determine the acreages that yield, or are capable of yielding, oil in paying quantities so that the owners thereof may be assessed for their pro rata of the tax levied for the support of the Department.

"The procedure for determining proved oil land is based on engineering principles. A definition[9] of proved oil land, as determined by this Department, is as follows:

> *'Proved oil land is that land which is determined, by the records of oil produced therefrom supported by geologic data, to be capable of yielding oil in paying quantities.'*

"It is thought that the Department's method of classifying proved oil land is a conservative one. Undrilled areas, lying between producing areas and lying where correlative geological conditions can be established with reasonable certainty, will show a greater acreage of proved oil land than undrilled areas lying beyond the outer limits of producing areas. In some cases, under the latter condition, the boundary line for proved oil land is drawn only one well location away from the nearest producing well. Boundaries are made to conform with the lines of legal subdivisions wherever possible.

"The spacing of wells varies greatly within each oil field and, in arriving at the average allotted acreage per well, the spacing in numerous tracts in each field was determined, weighed by the acreages involved, and averaged for the field. These field averages, therefore, do not reflect nor emphasize the conditions of either maximum or minimum spacing and, of course, the accuracy of the average acreage per well drilled, as shown in Table I, depends largely upon the care and judgment exercised in determining sample spacings of various tracts in each field.

* * * * * * *

"The following are a few examples of the variation in spacings or well areas. In the North Midway field the well areas vary from 2.2 acres to 4.6 acres, in the Buena Vista hills the average well areas are 9.5 acres and many tracts show 10 acres per well. On the Twenty-five Hill area the average spacing is between 2.0 and 2.5 acres per well. The spacing of wells in the East Side Coalinga field varies from 3.0 to 10.0 acres per well, and on the West Side from 4.2 to 8.0 acres per well. McKittrick and Kern River show the lowest acreages per well for the San Joaquin Valley fields. In the coast fields Lompoc and Santa Maria show the largest acreages per well. In several of the larger tracts of the Santa Maria field wells are spaced 1100 feet apart. In Ventura County the Bardsdale oil field shows the lowest acreage per well. Long Beach, Santa Fe Springs and Huntington Beach oil fields in southern California show average acreages which obscure the minimum acreages brought about by town lot drilling. For example, average acreages vary at Santa

[8]Collom, R. E., California's proved oil and gas fields: Summary of Operations, Cal. Oil Fields, Cal. State Min. Bur., Vol. 8, pp. 15-18, Aug., 1922.

[9]Collom, R. E., Proved oil land: Cal. State Min. Bur., Summary of Operations, California Oil Fields, Vol. 7, No. 2, August, 1921, pp. 5-9.

Fe Springs from 1.5 to 8 acres per well. Included within the data of the 1.5 acre minimum are town lot tracts in which locations are as close as 3 wells per acre.

"In estimating the average acreages per well in any field as a whole, the spacing and number of offset locations of line wells causes a marked reduction in the average acreage and the smaller the tracts held by different owners, the closer and greater in number will be the offset locations.

"The average acreages per well as given herein are smaller than indicated on a basis of total proved acreages divided by the number of producing wells. * * * Using the average acreages per well for determining total developed acreages, and with liberal allowance for error, the data show that there is a large amount of acreage still undeveloped within the proved oil and gas fields of California. Further, it is the writer's opinion that some interesting and encouraging data, as to the quantities of oil still recoverable from the undeveloped areas alone, could be drawn by computations based on records of past productions and rates of decline of production in the areas already developed.

"According to the estimates the total undrilled area amounts to 54,214 acres for the present proved fields. In the Midway-Sunset fields alone the proved area is 46,301 acres, of which 19,135 acres is estimated as developed and therefore 27,166 acres as undeveloped. In Kern County the proved area is 68,866 acres. This includes 15,360 acres of federal lands[10] of which approximately 2600 acres can be classed as developed.

"In the coastal fields, including those of Los Angeles and Orange counties, there is not such a wide margin between developed and undeveloped areas and, although the oil fields of Southern California are now undergoing intensive development, it appears that the fields of Kern County, notably Midway and Elk Hills, still hold a large part of California's petroleum and gas reserve for the future."

[10]In the computation of proved oil land for fixing the assessment rate for taxation, the quantity of proved land owned by the United States Government is omitted as it is not taxable by the state.

CHAPTER THREE.

METALS.

The total value of metals produced in California during 1922 was $21,700,733. The chief of these is, and always has been, gold, followed in order in 1922 by silver, copper, lead, quicksilver, zinc, platinum, iron ore and manganese ore. There was no production of antimony, cadmium, molybdenum, tin, nor tungsten, which have in the past been on the active list. Deposits of ores of nickel and vanadium have also been found in the state; although there has as yet been no commercial output of them. The above-noted total for this group is a net increase of $489,654 over the 1921 total of $21,211,079, due mainly to increases registered by copper, lead and zinc, in spite of decreases by gold and silver.

California leads all states in the Union in her gold production and is credited with approximately 30% of the nation's yield in 1922. The precious metal is widely distributed throughout the state. Thirty-one of the fifty-eight counties reported an output in 1922 from either mines or dredges.

Copper, which is second in importance among the metals of the state, occurs in the following general districts: the Shasta County belt, which has been by far the most important; the Coast Range deposits, extending more or less continuously from Del Norte in the north to San Luis Obispo County in the south; the Sierra Nevada belt, starting in Plumas and running in a general southerly and southeasterly direction through the Mother Lode counties and ending in Kern; the eastern belt in Mono and Inyo counties; and the southern belt, in San Bernardino, Riverside and San Diego counties.

Silver is not generally found alone in the state, except notably in the new Rand district, San Bernardino County; but is associated to a greater or less extent with gold, copper, lead and zinc.

Quicksilver has for many years been one of the state's staple products and California has supplied approximately 75% of the nation's output of this metal.

Tungsten is found in but few other localities of importance in the United States.

Large deposits of iron ore have been known in several sections of the state, but for various economic reasons this branch of the mineral industry thus far has made only slight progress on the Pacific Coast.

A comparison of the 1922 metal output with that of 1921 is afforded by the following table:

	1921		1922		Increase+ Decrease—
	Amount	Value	Amount	Value	Value
Copper	12,088,053 lbs.	$1,559,358	22,883,987 lbs.	$3,090,582	$1,531,224+
Gold		15,704,822		14,670,346	1,034,476—
Iron ore	1,970 tons	12,030	3,588 tons	18,868	6,838+
Lead	1,149,051 lbs.	51,707	6,511,280 lbs.	358,120	306,413+
Manganese ore	1,005 tons	12,210	540 tons	7,650	4,560—
Platinum	613 fine oz.	58,754	795 fine oz.	90,288	31,534+
Quicksilver	3,157 flasks	140,666	3,466 flasks	191,851	51,185+
Silver		3,629,223		3,100,065	529,158—
Zinc	846,184 lbs.	42,309	3,034,430 lbs.	172,963	130,654+
Total values		$21,211,079		$21,700,733	
Net increase					$489,654+

ALUMINUM.

Bibliography: Bulletins 38, 67. U. S. G. S., Min. Res. of U. S.

To date there has been no commercial production of aluminum ore in California. The first authentic find of bauxite in this state was noted in the April, 1922, issue of 'Mining in California' (see Report XVIII, page 198; also 'Pacific Mining News,' p. 13, May, 1922). It is in Riverside County, southeast of Corona, but as yet undeveloped.

Minerals containing aluminum are abundant, the most widely distributed being the clays. There are only two, however, thus far of consequence, commercially, in the production of the metal: bauxite (to which may be added the related, hydrated oxides, hydrargillite and diaspore), and cryolite. Cryolite is found in commercial quantities only in South Greenland, and was formerly the only ore of aluminum used, being still employed as a flux in the extraction of the metal. Bauxite has been, for some years, the most important source of aluminum and its salts. Its color varies from gray to red, according to the amount of iron present, the composition ranging usually between the following limits: Al_2O_3, 30%–60%; Fe_2O_3, 3%–25%; SiO_2, 0.5%–20%; TiO_2, 0.0%–10%. Besides its reduction to the metal, bauxite is also utilized in the manufacture of: aluminum salts, refractory bricks, alundum (fused alumina) for use as an abrasive; and in the refining of oil (stated to be of growing importance). The most important producing countries, both of bauxite and the metal, are the United States and France, the former yielding more than 60 per cent of the world's output. In 1913 France led.

Because of its light weight (2.58 specific gravity), the metal, aluminum, has many important industrial uses, particularly in the manufacture of aeroplanes, airships, automobiles, cooking utensils, and electrical apparatus. The use of aluminum dust in place of zinc dust for precipitating precious metal from cyanide solutions is increasing. In the Thermit process of welding and casting, aluminum in fine grains or filings is mixed with the oxide (usually iron oxide) to be reduced.

Present quotations for aluminum are 25¢–27¢ per pound, according to grade, for the refined metal.

ANTIMONY.

Bibliography: State Mineralogist Reports VIII, X, XII, XIII, XIV, XV, XVII. Bulletin 38.

Production of antimony in California has been irregular, and small in amount except during the year 1916 when the high war-time prices permitted American producers, for a short period, to compete with Chinese antimony. The principal commercial production of antimony in California has come from Kern, Inyo, and San Benito counties, and other occurrences have been noted in Nevada, Riverside, and Santa Clara counties. The commonest occurrence is in the form of the sulphide, stibnite; but in the Kernville, and Havilah districts in Kern County there were notable deposits of the native metal, being among the few localities of the world where native antimony has been found.

California producers claim that they can not operate profitably unless the price of antimony be above 12 cents per pound. Present New York quotations are around 7 cents per pound.

Pure antimony metal, and manufactured antimony compounds are of considerable importance as pigments in the ceramic industry. The most important use of the metal, commercially, is in various alloys, particularly type-metal (with tin and lead), babbitt (with tin and copper), and britannia metal (with tin and copper).

The production of antimony in California by years since 1887 has been as follows:

Year	Tons	Value	Year	Tons	Value
1887	75	$15,500	1900	70	$5,700
1888	100	20,000	1901	50	8,350
1889	--------	----------	1902	--------	----------
1893	50	2,250	1915	510	35,666
1894	150	6,000	1916	1,015	64,793
1895	33	1,485	1917	158	18,786
1896	17	2,320	1918	--------	----------
1897	20	3,500			
1898	40	1,200	Totals	2,363	$199,050
1899	75	13,500			

ARSENIC.

Bibliography: Bulletin 67. U. S. G. S., Min. Res. of U. S.

Arsenic is found in a number of localities in California in the mineral arsenopyrite (FeAsS), which is frequently gold bearing; and in scorodite ($FeAsO_4+2H_2O$), an oxidation product of arsenopyrite. The occurrence of realgar (AsS) has also been noted (see Report XVIII, page 197). To date, there has been no commercial output of arsenic from California ores. The principal source of the arsenic of commerce in the United States has been as a by-product from the metallurgical treatment of copper, gold, and lead ores. It is usually recovered in the form of the tri-oxide, or 'white arsenic,' for which there is a demand for the preparation of insecticides, for use in agriculture and horticulture, and especially against the cotton-boll weevil in the southern states.

BISMUTH.

Bibliography: Bulletins 38, 67. Am. Jour. Sci. 1903, Vol. 16.

Several bismuth minerals have been found in California, notably native bismuth and bismite (the ochre) in the tourmaline gem district in San Diego and Riverside counties near Pala. Other occurrences of bismuth minerals, including the sulphide, bismuthinite, have been noted in Inyo, Fresno, Nevada, Tuolumne, and Mono counties, but only in small quantities. The only commercial production recorded was 20 tons valued at $2,400, in 1904. and credited to Riverside County.

In 1917, a few pounds of bismuthinite (Bi_2S_3) with associated bismutite ($Bi_2CO_5.H_2O$), was taken out at the United Tungsten Copper Mine, in the Morongo district, San Bernardino County. It is associated with scheelite in a contact deposit between limestone and granite.

Recovery of bismuth from blister copper in the electrolytic refinery has been noted,[1] ranging as high as 27.3 pounds of metallic bismuth per 100 tons of blister copper from the Iron Mountain, Shasta County, ores. In the United States, the principal recovery of bismuth is obtained as a by-product from the refining of lead bullion.

The uses of bismuth are somewhat restricted, being employed principally in the preparation of medicinal salts, and in low melting-point or cliché alloys. These alloys are utilized in automatic fire sprinkler systems, in electrical fuses, and in solders.

Present quotations for bismuth are $2.55 per pound for the refined metal.

CADMIUM.

Bibliography: U. S. G. S., Min. Res. of U. S., 1908, 1918.

During 1917 and 1918, cadmium metal was recovered by the electrolytic zinc plant of the Mammoth Copper Company in Shasta County. It was shipped in the form of 'sticks' and amounted to a total of several thousand pounds for the two years, the exact figures being concealed under 'Unapportioned.' That was the first, and thus far the only, commercial production of cadmium recorded from California ore. Cadmium there occurs associated with zinc sulphide, sphalerite, probably as the sulphide, greenockite. Cadmium also occurs in the Cerro Gordo Mine, Inyo County, associated with smithsonite (zinc carbonate).

There are several cadmium minerals, but none of them occur in sufficient quantities individually to be profitable as distinct ores. The cadmium of commerce is derived as a by-product in the reduction of zinc minerals and ores, in nearly all of which it occurs in at least minute proportions, the average ratio being about 1 of cadmium to 200 of zinc. As cadmium behaves metallurgically much the same as zinc, it constitutes a fraction of 1 per cent of nearly all metallic zinc.

Cadmium is produced in United States in two forms—metallic cadmium and the pigment, cadmium sulphide. The principal use of the metal is in low-melting point, or cliché alloys, and its salts are utilized in the arts, medicine, and in electroplating. The sulphide is employed as a paint pigment, being a strong yellow, which is unaffected

[1]Trans. Am. Inst. Min. Eng., Vol. 47, pp. 217-218.

by hydrogen sulphide gas from coal smoke. It is also employed in coloring glass and porcelain. Cadmium cliché metal is stated to be superior to the corresponding bismuth alloy, for making stereotype plates. Cadmium is also used in bronze telegraph and telephone wires, and gives some promise of being utilized in electroplating.

Present quotations for cadmium are $1.15 per pound for the refined metal.

COBALT.

Bibliography: Report XIV. Bulletin 67. U. S. G. S., Min. Res. of U. S., 1912, 1918.

Occurrences of some of the cobalt minerals have been noted in several localities in California, but to date no commercial deposits have been developed. Some of the copper ores of the foothill copper belt in Mariposa and Madera counties have been found to contain cobalt up to 3%.

The most important use of cobalt is in the manufacture of the alloy, stellite, in which it is combined with chromium, for making high-speed lathe tools, and non-tarnishing cutlery and surgeons' appliances. The metal is also used in electroplating, similarly to nickel; and the oxide, carbonate, chloride, sulphate and other salts are used in ceramics for coloring. Some of the organic salts of cobalt (acetate, resinate, oleate) are employed as 'driers' in paint and varnish.

Present quotations for cobalt are $2.65–$2.85 per pound for the refined metal.

COPPER.

Bibliography: State Mineralogist Reports VIII–XVIII (inc.). Bulletins 23, 50, 91.

Copper is second only to gold, among the metals produced in California. For many years Shasta was the leading county in the output of the red metal, but in 1919 Plumas advanced to first place, which it has since retained. This was due to the maintenance of output level by the Engels property in Plumas County and to the shutting down of the Mammoth, Mountain and Afterthought groups in Shasta County. The increase in 1922 is due to the return of the Walker Mine, Plumas County, to the producing column. Both the Engels and Walker ores are treated by flotation and the concentrate shipped to Utah plants for smelting. The fact that the Engels ore carries appreciable values in gold and silver has been an important factor in the company's maintenance of operations during this period that practically all other copper mines in the state have been closed. A small yield of copper in 1922 was also reported from Inyo, San Bernardino, Placer, Trinity, and Mono counties.

Although the copper property of the Mountain Copper Company was nonproductive in 1921–1922, a part of the copper credited to Shasta County the past two years was obtained as a by-product from pyrites which had been sold and utilized in the manufacture of sulphuric acid, after which the cinder was smelted at other plants. Some copper was also obtained from matte made by the Shasta Zinc and Copper Company at Winthrop (Bully Hill) in their reverberatory operations for the production of zinc oxide.

The state's total for 1922 amounted to 22,883,987 pounds, valued at \$3,090,582, being practically double the 1921 figures of 12,088,053 pounds, and \$1,559,358. The average price in 1922 was 13.5¢ as against 12.9¢ in 1921, and 18.4¢ in 1920; and was approximately equal to the pre-war price of 13.3¢ of the year 1913. The high-level year was 1917 with an average of 27.3¢. With the notable exception of the Engels group in Plumas County (and in 1922, the Walker), all of California's important copper producers have been closed down since the middle of the year 1919, owing to the unfavorable market, a condition which has been world-wide.

Distribution of the 1922 copper output, by counties, was as follows:

County	Pounds	Value
Inyo	69,537	\$9,388
Mono	4,338	586
Plumas	20,677,771	2,791,499
San Bernardino	13,452	1,816
Shasta	1,827,875	246,763
Calaveras, Kern, Nevada, Trinity*	291,014	40,530
Totals	22,883,987	\$3,090,582

*Combined to conceal output of a single operator in each.

Copper Production of California, by Years.

Amount and value of copper producton in California annually since such records have been compiled by the State Mining Bureau is given in the following tabulation:

Year	Pounds	Value	Year	Pounds	Value
1887	1,600,000	\$192,000	1906	28,726,448	\$5,522,712
1888	1,570,021	235,303	1907	32,602,945	6,341,387
1889	151,505	18,180	1908	40,868,772	5,350,777
1890	23,347	3,502	1909	65,727,736	8,478,142
1891	3,397,455	424,675	1910	53,721,032	6,680,641
1892	2,980,944	342,808	1911	36,838,024	4,604,753
1893	239,682	21,571	1912	34,169,997	5,638,049
1894	738,594	72,486	1913	34,471,118	5,343,023
1895	225,650	21,901	1914	30,491,535	4,055,375
1896	1,992,844	199,519	1915	40,968,966	7,169,567
1897	13,638,626	1,540,666	1916	55,809,019	13,729,017
1898	21,543,229	2,475,168	1917	48,534,611	13,249,948
1899	23,915,486	3,990,534	1918	47,793,046	11,805,883
1900	29,515,512	4,748,242	1919	22,162,605	4,122,246
1901	34,931,788	5,501,782	1920	12,947,299	2,382,303
1902	27.860,162	3,239,975	1921	12,088,053	1,559,358
1903	19,113,861	2,520,997	1922	22,883,987	3,090,582
1904	29,974,154	3,969,995			
1905	16,997,489	2,650,605	Totals	851,215,542	\$141,293,672

*Combined to conceal output of a single operator in each.

GOLD.

Bibliography: State Mineraloigist Reports I to XIX (inc.). Bulletins 36, 45, 57, 91. U. S. Geol. Surv., Prof. Paper 73.

Gold was the first and, for many years, the most important single mineral product of California. Although now surpassed for a number of years in annual value by petroleum, and by cement during the past three years, it still heads our metal list, and California continues to outrank all the other gold-producing states of the United States, including Alaska. In fact for 1922, California produced one-third of the gold mined in the entire United States.

Headframe and timber yard at the Empire Mine, Grass Valley, Nevada County. One of the important gold producers of California.

The increases in costs of all supplies, labor, and transportation beginning in 1915 made it increasingly difficult in the period following for the gold miner to operate at a profit. Many mines were forced to close down, and the gold output of not only California, but of the other western gold states, decreased greatly. Economic conditions are now slowly improving, and gold production will no doubt soon again strike an upward trend. The 1922 figures show a decrease from the 1921 yield. The continued shut-down of all but two of the large copper properties, which have always been important producers of by-product gold and silver, has also been an important factor.

Outlook for 1923.

According to the mid-year review of the U. S. Geological Survey[1] for the first six months of 1923,

[1]U. S. Geol. Surv., Press Bulletin July 15, 1923.

"mining in California during the first half of 1923 has been greatly handicapped by lack of efficient labor and by a very large labor turnover. Considerable development and prospecting work have been done during the first six months of the year in different parts of the State, particularly in the gold districts. Most of the larger gold mines are operating about as they were in 1922, and a few new gold producers have started production. The silver mines have been worked to their full capacity thus far in 1923, but some curtailment of activity in silver mining took place in June. With the resumption of open-market prices for silver it may be expected that the production of that metal will be further reduced. The Engels and Walker mines have been operating at full capacity, and steps have been taken to increase the output at both properties. It is reported that the copper mines in Shasta County and the Calaveras Copper Co. may reopen in the near future.

* * * * * * *

"The output of both gold and silver during the first half of 1923 did not come up to that during the corresponding period, in 1922, but the increase in production by copper and lead mines will probably offset the decrease of silver from the silver mines, so that the output for 1923 will probably about equal that for 1922, which was valued at $21,625,600."

Production in 1922.

The State Mining Bureau has never independently collected statistics of gold and silver production, as there is no necessity for duplicating the very thoroughly organized work of the U. S. Geological Survey covering those metals. The data here given relative to these two metals have been received through the courtesy and cooperation of Mr. J. M. Hill, Statistician in Charge of the San Francisco branch office of the Division of Mineral Resources. Anyone wishing fuller details of the production of these metals may obtain the same by applying to the U. S. Geological Survey, Washington, D. C., or to room 305, U. S. Custom House, San Francisco, California, for a copy of the 'separate' on the subject.

The gold production of California for 1922 was distributed, by counties, as follows:

County	Value	County	Value
Amador	$2,241,100	Plumas	$223,025
Butte	491,201	Sacramento	1,350,749
Calaveras	1,413,465	San Bernardino	125,728
El Dorado	47,340	Shasta	393,034
Fresno	10,442	Sierra	1,753,242
Humboldt	1,330	Siskiyou	75,105
Imperial	350	Trinity	182,918
Inyo	85,265	Tuolumne	222,366
Kern	124,337	Yuba	2,492,948
Madera	1,594	Colusa, Del Norte, Lassen, Los Angeles, Orange, San Diego, Merced, Stanislaus*	127,243
Mariposa	218,571		
Mono	65,747		
Nevada	2,903,573		
Placer	119,673	Total value	$14,670,346

*Combined to conceal output of a single operator in each.

The following is quoted from the advance chapter on Gold in 1922, by courtesy of Mr. J. M. Hill of the U. S. Geological Survey:

"The gold production of California in 1922 was 709,677.98 ounces, valued at $14,670,346, a decrease of 50,042.78 ounces, or $1,034,476, as compared with the gold yield of 1921. In 1922 deep mines produced 62.51 per cent and placer mines 37.49 per cent of the gold output. In 1921 the relation was deep mines 48 per cent and placers 52 per cent, whereas in 1920 deep mines produced 51 per cent and placer mines 49 per cent of the gold output. The 282 placer mines operated in California in 1922, for the most part, were relatively small operations. Aside from the dredges there were only 2 placer mines, both drift, at which over $20,000 in gold was recovered.

"The placer gold yield in 1922 was 266,055.50 ounces, valued at $5,499,855, which is $2,654,969 less than the value of gold produced at placer mines in 1921. Dredges produced 91 per cent, drift mines 5 per cent, hydraulic mines 3 per cent, and surface placers 1 per cent of the total yield of gold from placers in 1922. During the year there were 35 dredges, 63 drift, 60 hydraulic, and 124 surface placers at which gold was produced. Dredges in 1922 produced $2,757,572 less gold than in 1921, the greater

part of the loss being from the Yuba River field in Yuba County, though the dredges in Amador, Calaveras, Placer, Sacramento, and Trinity counties all saved smaller quantities of gold than in 1921. The dredges in Butte, Stanislaus, and Shasta counties saved more gold in 1922 than in the previous year.

"Gold produced at drift mines in 1922 was $125,215 greater than in 1921, the principal increase being from drift mines in Plumas, Sierra, Butte, and Calaveras counties. There was a decrease of $4,533 in the gold yield from hydraulic mines in 1922, as compared with 1921. Hydraulic mines in Trinity and Siskiyou were not so productive as in 1921, but in Amador, Calaveras, Nevada, Plumas, and Sierra counties there were increased yields from hydraulic mines. The production of gold from surface mines in 1922 was $18,079 less than in 1921. The output from this source varies considerably from year to year, depending largely on labor conditions.

"The production of gold from deep mines in 1922 was 413,622.48 ounces, valued at $9,170,491, an increase of $1,620,493, as compared with the yield of gold from deep mines in 1921. Of the 283 deep mines, which produced gold in 1922, at only 31 was the yield of gold valued at more than $20,000 and at only 7 more than $400,000. At 4 deep mines gold was produced in excess of $1,000,000. Nevada County was first, closely followed by Amador, in gold yield from deep mines; in the former county the value of the gold produced was over $2,800,000 and in the latter county over $2,200,000. Sierra County with a yield of over $1,700,000 from deep mines was third in rank in 1922, and Calaveras County deep mines were fourth, with a production of over $1,200,000. The next nearest competitors were Mariposa with $214,000, and Tuolumne with $212,000. There were material increases in the output of gold produced at deep mines in Amador, Mono, Nevada, Plumas, Shasta, Sierra, Siskiyou, and Tuolumne counties, but the most noteworthy gain was from the deep mines of the Alleghany district in Sierra County. The Nevada City-Grass Valley mines were more productive than in 1921, and the output of gold from Jackson, Amador County, was not reduced in spite of the fire at the Argonaut mine.

"The dry gold ores mined in 1922, a total of 984,785 tons, yielded 97 per cent of the gold produced at deep mines and 61 per cent of the total gold produced at both deep and placer mines. Dry silver and copper ores each carried about 1.5 per cent of the gold from deep mines. Bullion made at gold and silver mills carried 84 per cent, concentrates made at all classes of mills 14 per cent, and smelting ore 2 per cent of the total gold produced by deep mines in 1922."

Total Gold Production of California.

The following table was originally compiled by Chas. G. Yale, of the Division of Mineral Resources, U. S. Geological Survey, but for a number of years statistician of the California State Mining Bureau and the U. S. Mint at San Francisco. The authorities chosen for certain periods were: J. D. Whitney, state geologist of California; John Arthur Phillips, author of "Mining and Metallurgy of Gold and Silver" (1867); U. S. Mining Commissioner R. W. Raymond; U. S. Mining Commissioner J. Ross Browne; Wm. P. Blake, Commissioner from California to the Paris Exposition, where he made a report on "Precious Metals" (1867); John J. Valentine, author for many years of the annual report on precious metals published by Wells, Fargo & Company's Express; and Louis A. Garnett, in the early days manager of the San Francisco refinery, where records of gold receipts and shipments were kept. Mr. Yale obtained other data from the reports of the director of the U. S. Mint and the director of the U. S. Geological Survey. The authorities referred to, who were alive at the time of the original compilation of this table in 1894, were all consulted in person or by letter by Mr. Yale with reference to the correctness of their published data, and the final table quoted was then made up.

The figures since 1904 are those prepared by the U. S. Geological Survey:

Year	Value	Year	Value
1848	$245,301	1886	$14,716,506
1849	10,151,360	1887	13,588,614
1850	41,273,106	1888	12,750,000
1851	75,938,232	1889	11,212,913
1852	81,294,700	1890	12,309,793
1853	67,613,487	1891	12,728,869
1854	69,433,931	1892	12,571,900
1855	55,485,395	1893	12,422,811
1856	57,509,411	1894	13,923,281
1857	43,628,172	1895	15,334,317
1858	46,591,140	1896	17,181,562
1859	45,846,599	1897	15,871,401
1860	44,095,163	1898	15,906,478
1861	41,884,995	1899	15,336,031
1862	38,854,668	1900	15,863,355
1863	23,501,736	1901	16,989,044
1864	24,071,423	1902	16,910,320
1865	17,930,858	1903	16,471,264
1866	17,123,867	1904	19,109,600
1867	18,265,452	1905	19,197,043
1868	17,555,867	1906	18,732,452
1869	18,229,044	1907	16,727,928
1870	17,458,133	1908	18,761,559
1871	17,477,885	1909	20,237,870
1872	15,482,194	1910	19,715,440
1873	15,019,210	1911	19,738,908
1874	17,264,836	1912	19,713,478
1875	16,876,009	1913	20,406,958
1876	15,610,723	1914	20,653,496
1877	16,501,268	1915	22,442,296
1878	18,839,141	1916	21,410,741
1879	19,626,654	1917	20,087,504
1880	20,030,761	1918	16,529,162
1881	19,223,155	1919	16,695,955
1882	17,146,416	1920	14,311,043
1883	24,316,873	1921	15,704,822
1884	13,600,000	1922	14,670,346
1885	12,661,044		
		Total	$1,750,593,269

IRIDIUM (see under Platinum).

IRON ORE.

Bibliography: State Mineralogist Reports II, IV, V, X, XII, XIII, XIV, XV, XVII, XVIII. Bulletins 38, 67, 91. Am. Inst. Min. Eng., Trans. LIII. Min. & Sci. Press, Vol. 115, pp. 112, 117–122; Vol. 123, pp. 94–96, 113–114.

Iron ore to the amount of 3588 tons, valued at $18,868, was produced in California during the year 1922, and utilized for foundry flux and in steel refining at open-hearth plants. There is also some tonnage utilized in the manufacture of paint pigment, and which is credited to 'mineral paint' in these statistical reports. This 1922 yield is an increase over the 1970 tons and $12,030 of 1921.

There are considerable deposits of iron ore known in California, notably in Shasta, Madera, Placer, Riverside and San Bernardino coun-

ties, but production has so far been limited for lack of an economic supply of coking coal. This missing link bids fair to be supplied in the near future (see under Coal). Some pig-iron has been made, utilizing charcoal for fuel, both in blast furnaces and by electrical reduction. Further developments along the line of electrical smelting, or discoveries making available our petroleum fuel, for iron reduction, would lead to considerable increase of iron mining in California. For the present, at least, the most feasible possibilities would seem to lie in utilizing our iron resources in the preparation of the various alloys such as ferro-chrome, ferro-manganese, ferro-molybdenum, ferro-silicon and ferro-tungsten, by means of the electric furnace. California possesses commercial deposits of ores of all the metals just enumerated.

The subject of establishing an iron industry on the Pacific Coast was dealt with somewhat in detail in the 1921 statistical report of the State Mining Bureau (see 'Mining in California,' April 1922, pp. 188–190).

Total Iron Ore Production of California.

Total iron ore production in California, with annual amounts and values, is as follows:

Year	Tons	Value	Year	Tons	Value
1881*	9,273	$79,452	1911	558	$558
1882	2,073	17,766	1912	2,508	2,508
1883	11,191	106,540	1913	2,343	4,485
1884	4,532	40,983	1914	1,436	5,128
1885	------	------	1915	724	2,584
1886	3,676	19,250	1916	3,000	6,000
1887	------	------	1917	2,874	11,496
1893	250	2,000	1918	3,108	15,947
1894	200	1,500	1919	2,300	13,796
1895	------	------	1920	5,975	40,889
1907	400	400	1921	1,970	12,030
1908	------	------	1922	3,588	18,868
1909	108	174			
1910	579	900	Totals	62,616	$503,251

*Productions for the year 1881-1886 (inc.) were reported as "tons of pig iron" (U. S. G. S., Min. Res. 1885), and for the table herewith are calculated to "tons of ore" on the basis of 47.6% Fe as shown by an average of analyses of the ores (State Mineralogist Report IV, p. 212). This early production of pig iron was from the blast furnaces then in operation at Hotaling in Placer County. Charcoal was used in lieu of coke. Though producing a superior grade of metal, they were obliged finally to close down, as they could not compete with the cheaper English and eastern United States iron brought in by sea to San Francisco.

LEAD.

Bibliography: State Mineralogist Reports IV, VIII–XV (inc). XVII, XVIII.

Lead production in California in 1922 increased to nearly six times that of the preceding year, but was still below the record yield of the years 1916–1918. The principal output was from lead-silver ores from Inyo County, with smaller amounts from Shasta, Mono and San Bernardino counties. The average price of the year was 5.5¢ per pound as compared with 4.5¢ in 1921, 3.9¢ in 1913, and the high-level average of 8.7¢ per pound in 1917.

The 1922 production was distributed by counties, as follows:

County	Pounds	Value
Inyo	6,264,138	$344,528
Mono	9,820	540
San Bernardino	11,188	615
Imperial, Kern, Nevada, Orange, and Shasta*	226,134	12,437
Totals	6,511,280	$358,120

*Combined to conceal output of a single operator in each.

Lead Production of California, by Years.

Statistics on lead production in California were first compiled by this Bureau in 1887. Amount and value of the output, annually, with total figures, to date, are given in the following table:

Year	Pounds	Value	Year	Pounds	Value
1887	1,160,000	$52,200	1906	338,718	$19,307
1888	900,000	38,250	1907	328,681	16,690
1889	940,000	35,720	1908	1,124,483	46,663
1890	800,000	36,000	1909	2,685,477	144,897
1891	1,140,000	49,020	1910	3,016,902	134,082
1892	1,360,000	54,400	1911	1,403,839	63,173
1893	666,000	24,975	1912	1,370,067	61,653
1894	950,000	28,500	1913	3,640,951	160.202
1895	1,592,400	49,364	1914	4,697,400	183,198
1896	1,293,500	38,805	1915	4,796,299	225,426
1897	596,000	20,264	1916	12,392.031	855,049
1898	655,000	23,907	1917	21,651,352	1,862,016
1899	721,000	30,642	1918	13,464,869	956,006
1900	1,040,000	41,600	1919	4,139,562	219,397
1901	720,500	28,820	1920	4,903,738	392,300
1902	349.440	12,230	1921	1,149,051	51,707
1903	110,000	3.960	1922	6,511,280	358,120
1904	124,000	5,270			
1905	533,680	25,083	Totals	103,266,220	$6,348,896

MANGANESE.

Bibliography: State Mineralogist Reports XII, XIII, XIV, XV, XVIII. Bulletins 38, 67, 76, 91. U. S. G. S., Bull. 427.

By far the greater tonnage of manganese ore is utilized in the preparation of ferro-manganese and employed in the steel industry both for its metal content and to slag off certain impurities during the open-hearth treatment. Though its other uses may be classed as 'chemical,' the tonnage thus consumed is relatively smaller. Its chemical uses are as a decolorizer or oxidizer in glass manufacture, and as a constituent in electric dry batteries. In the paint trade, the black dioxide is used as a drier in varnish. One of the newer uses of these black, oxide ores of manganese is in the manufacture of pressed and fancy brick, in the composition of which it is mixed in powdered form to deepen the color.

The chemical uses require a much higher grade of manganese ore than the steel industry. In making ferro-manganese, carbonate ore can be utilized as well as the oxides; but for chemical purposes the dioxide is the important constituent. For steel purposes an iron content

is acceptable, but manganese should exceed 40%. Silica should be under 8%, though higher was taken during the war period. Phosphorus should be under 0.20%. For electric dry cells, the iron content should be under 1.5% Fe_2O_3, and SiO_2, under 6%. For glassmaking the manganese should be practically free of iron. On account of the high prices prevailing for manganese during 1915–1918, selenium replaced manganese dioxide in glass factories; and it is stated to have been so successful that its use continues.

Though the imports of manganese ore from the Caucasus District in Russia were reduced by the war to practically nothing, the United States received important shipments from Brazil, India and Cuba; so that the total imports for 1916 were practically double those of either 1914 or 1915. The 1916 figures were 576,321 long tons, valued at $8,666,179; for 1917, a total of 629,972 long tons, valued at $10,262,929, of which 512,517 tons were from Brazil; in 1918 a total of 491,303 long tons, value $15,095,867, of which 345,877 tons were from Brazil; in 1919, a total of 333,344 long tons, value $11,229,184, of which 246,592 tons came from Brazil; in 1920, total 601,437 long tons, value $11,955,922, with 421,523 tons, Brazil; in 1921, total 401,354 long tons, $3,365,732, with 262,468 tons, Brazil. In 1922 up to Sept. 22, when the new tariff became effective, a total of 327,727 long tons, valued at $2,695,724 was imported; and 46,724 tons, value $704,040 for the remainder of the year. The Tariff Act of 1922 provides: "Manganese ore or concentrates containing in excess of 30 per centum of metallic manganese, 1 cent per pound on the metallic manganese contained."

Batteries, chemicals, and kindred industries in the United States consume approximately 25,000 tons of high-grade manganese ore, annually, or about one-thirtieth of that used in steel manufacture.

A considerable portion of the state's 1917–1918 product was utilized in California in making ferro-manganese by electric furnace; besides shipments which were sent East. Some 'chemical' ore was also shipped. For many years the principal producing section has been the Livermore-Tesla District, in Alameda and San Joaquin counties, but exceeded in 1915 by Mendocino and regaining the lead in 1916. Since 1918 the largest producing county has been Stanislaus, which adjoins San Joaquin on the south, and whose manganese district is a part of the same geological province that includes the Livermore-Tesla District.

Manganese is reported to exist in many localities in the state; but for a number of years, particularly since the discontinuance of the chlorination process in the metallurgy of gold, production was relatively unimportant until the activity of the war period, 1915–1919, since which it has returned to smaller figures.

The production of manganese ore in California for 1922 amounted to 540 tons of all grades, having a total value of $7,650 f. o. b. rail-shipping point. This was a decrease both in quantity and value from the 1921 figures. The prices paid in 1922 ranged from $6 to $18 per short ton, the average being approximately $14 per ton. The ores produced in California in 1922 were utilized mainly by the brick, paint, and glass trade; and came from Alameda, San Joaquin, and Stanislaus counties.

Manganese Production in California, by Years.

Production of manganese ore in California began at the Ladd Mine, San Joaquin County, in the Tesla District in 1867. When shipments of this ore to England ceased late in 1874, upwards of 5000 tons had been produced by that property. For some years following that, the output was small. The tabulation herewith shows the California output of manganese ore, annually, since 1887, when the compilation of such figures was begun by the State Mining Bureau:

Year	Tons	Value	Year	Tons	Value
1887	1,000	$9,000	1906	1	$30
1888	1,500	13,500	1907	1	25
1889	53	901	1908	321	5,785
1890	386	3,176	1909	3	75
1891	705	3,830	1910	265	4,235
1892	300	3,000	1911	2	40
1893	270	4,050	1912	22	400
1894	523	5,512	1913	--------	--------
1895	880	8,200	1914	150	1,500
1896	518	3,415	1915	4,013	49,098
1897	504	4,080	1916	13,404	274,601
1898	440	2,102	1917	15,515	396,659
1899	295	3,165	1918	26,075	979,235
1900	131	1,310	1919	11,569	451,422
1901	425	4,405	1920	2,892	62,323
1902	870	7,140	1921	1,005	12,210
1903	1	25	1922	540	7,650
1904	60	900			
1905	--------	--------	Totals	84,639	$2,322,999

MOLYBDENUM.

Bibliography: Reports XIV, XVII. Bulletin 67. U. S. Bur. of Min., Bulletin 111. Proc. Colo. Sci. Soc., Vol. XI.

Molybdenum is used as an alloy constituent in the steel industry, and in certain forms of electrical apparatus. Included in the latter, is its successful substitution for platinum and platinum-iridium in electric contact making and breaking devices. In alloys it is used similarly to and in conjunction with chromium, cobalt, iron, manganese, nickel, tungsten, and vanadium. The oxides and the ammonium salt have important chemical uses.

The two principal molybdenum minerals are: the sulphide, molybdenite; and wulfenite, lead molybdate; the former furnishing practically the entire commercial output. Molybdenite is found in or associated with acidic igneous rocks, such as granite and pegmatite. The chief commercial sources have been New South Wales, Queensland, and Norway, with some also from Canada.

Deposits of disseminated molybdenite are known in several localities in California, and in at least two places it occurs in small masses associated with copper sulphides. The only recorded commercial shipments of molybdenum ore in California were during the war, 1916–1918. Some development work has recently been done on a high-grade deposit at the head of the Kaweah River, Tulare County.

The 1917 output included some concentrates assaying up to 58% MoS_2 but the bulk of it was 1.5% ore which was shipped to Denver, Colorado, for concentration. That production came mainly from Shasta County, with smaller amounts from Inyo, Mono and San Diego counties. There were two concentrating plants built in California—one in each of the above first and last named counties.

In the spring of 1918, a flotation plant operated for a short time by a lessee on the Boulder Creek Mine, near Gibson Siding, Shasta County, made a small amount of 90% MoS_2 concentrate. The ore treated carried 2.6% MoS_2. There has been none produced in California since 1918.

Present quotations for molybdenum ore are @ 75¢ per pound for 85% MoS_2 concentrates, plus duty.

The California production of molybdenum ore by years is summarized in the following tabulation:

Year	Tons	Value
1916	8	$9,945
1917	243	9,014
1918	*	300
Totals	251	$19,259

*300 pounds of 90% MoS_2 concentrate.

NICKEL.

Bibliography: Reports XIV, XVII. U. S. G. S., Bulletin 640-D.

Nickel occurs in the Friday Copper Mine in the Julian District, San Diego County. The ore is a nickel-bearing pyrrhotite, with some associated chalcopyrites. Some ore has been mined in the course of development work, but not treated nor disposed of, as they were unable to get any smelter to handle it for them. Nickel ore has also been reported from other localities in California, but not yet confirmed.

Present quotations for nickel are 27¢–32¢ per pound, according to grade and quantity.

OSMIUM (see under Platinum).

PALLADIUM (see under Platinum).

PLATINUM.

Bibliography: State Mineralogist Reports IV, VIII, IX, XII-XVIII. Bulletins 38, 45, 67, 85, 91. U. S. Geol. Surv. Bulletins 193, 285. Trans. Am. Inst. Min. Eng., Vol. 47, pp. 217–218.

In California, platinum is obtained as a by-product from placer operations for gold. The major portion of it comes from the dredges working in Butte, Calaveras, Sacramento, Shasta and Yuba counties, with smaller amounts from dredges in Amador, Stanislaus and Trinity, and from the hydraulic and surface sluicing mines of Del Norte, Humboldt, Siskiyou and Trinity.

During the last three years, quite a number of prospectors and small operators, working with rockers and panning have recovered amounts of platinum which, though individually small, have in the aggregate

added materially to the state's total yield. This is particularly true of the Beegum Creek District in southwestern Shasta County; also the New River and Hayfork districts in Trinity County.

The production of platinum-group metals in California for 1922 totals 937 ounces, crude, containing 795 fine ounces, valued at $90,288. Of this amount, a total of 898 ounces, crude, or 96%, came from the gold dredges. This is an increase of 182 fine ounces in quantity, and an increase of $31,534 in value compared with the 1921 figures. The prices prevailing in 1922 were materially higher than in 1921. From $70 to $113 per fine ounce was paid for platinum, and from $160 to $225 per fine ounce for iridium content in 1922.

The above-noted total of 898 fine ounces includes 570 fine ounces of osmiridium and iridium. Most of the platinum refiners pay for the osmiridium on the basis of its iridium content. Crude 'platinum' is really a mixture of the metals of that group, and carries varying percentages of platinum, iridium, and osmiridium or iridosmine, with occasionally some palladium. Some platinum and palladium are also recovered in the electrolytic refining of blister copper. Iron in greater or less amount is always alloyed naturally with native platinum, and usually some iridium and osmium.

For further detailed information on California's platinum resources, analyses, tests, et al., the reader is referred to Bulletin 85, issued by the State Mining Bureau, and to the April, 1922, issue of 'Mining in California', pages 158–172.

In addition, there is usually some platinum recovered as a by-product in the gold refinery of the Mint, but which can not be assigned to the territory of its origin for lack of knowing to which lots of gold it belongs. The San Francisco Mint is stated to have recovered as high as 100 ounces of platinum in a single year from this source, some of which unquestionably came from California mines.

For 1922, the distribution of California's platinum yield was as follows:

County	Fine ounces	Value
Butte	30	$3,826
Calaveras	22	2,160
Humboldt	4	413
Shasta	496	57,458
Trinity	12	1,223
Yuba	115	11,077
Amador, Del Norte, Mendocino, Plumas, Sacramento, Stanislaus*	116	14,131
Totals	795	$90,288

*Combined to conceal output of a single operator in each.

Russia, previous to 1916, was producing from 90% to 95% of the world's platinum, but for several years following was reduced to practically nothing; and has not yet recovered her former position. Colombia ranked in second place, but now leads. California is the leading producer in the United States.

Uses, Markets, and Consumption.

Besides its well-known uses in jewelry, dentistry and for chemical-ware, an important industrial development of recent years employs platinum as a catalyzer in the 'contact process' of manufacturing concentrated sulphuric acid. It is also necessary for certain delicate parts of the ignition systems in automobiles, motor boats, and aeroplanes. Experiments have been made to find alloys which can replace platinum for dishes and crucibles in analytical work, but so far with only slight success.

According to Hill[1] the apparent consumption of crude platinum in the United States in the last few years has been about 50,000 ounces a year, but the supply has been below normal for a number of years. In the United States, the demand for refined platinum metals has been approximately 145,000 ounces during recent years. About half this demand is filled by metals recovered from domestic and foreign crude platinum and by recoveries from gold, copper, and nickel refining, but importation of refined metals and the recoveries from sweeps and scrap materials is an essential part of the domestic supply. Prior to 1915 the annual consumption of platinum metals in the United States was about 160,000 ounces.

"The chemical industry uses platinum, palladium, iridium, and rhodium in the pure state and in alloys in various types of apparatus. Apparently the bulk of platinum apparatus contains from one-half of 1 per cent to 5 per cent of either iridium or rhodium and very small quantities of iron and silica, which are detrimental. Salts of the various metals are used as reagents in the chemical laboratories.

"The chemical industry is not considered a good or steady buyer of platinum metals. The electrical industry requires practically pure platinum and iridium to make the alloys for contact points. These alloys carry from 5 to 20 per cent iridium, dependent on the character of work they are to perform. It is understood that palladium-gold alloys are being used for telephone, telegraph, and signal equipment contacts, and rhodium-platinum alloys are used in the manufacture of thermo-couples. Less expensive metals, particularly tungsten and nickel-chrome alloys, are used in some electrical equipment, such as heating elements, where platinum was formerly used.

"The demand for platinum in the electrical field is good, but there is a tendency to develop substitutes which may further restrict the market. The dental industry consumes considerable amounts of platinum metals, but the recent developments are toward palladium rather than platinum. Palladium-gold alloys have been found entirely satisfactory for tooth pins, rivets, and for foil for the manufacture of artificial teeth. Formerly these articles were made of platinum and platinum-iridium alloys. The demand of the dental industry should continue good and may increase, for there is no immediate prospect of the utilization of base-metal substitutes for precious metals in this field.

"Practically all of the jewelers' demand is for the 5 or 10 per cent iridium-platinum alloys, which are sold by the refiners in the form of sheet, wire, or semifinished findings, such as rings and settings. The jewelers are the largest consumers of platinum in the world, as platinum has been found satisfactory for gem settings and its price is commensurate with the value of the gems. Unless fashion should otherwise decree, there seems to be no reason why this market for platinum should not increase rather than decrease.

"Crude platinum is sold in lots ranging from less than an ounce to hundreds of ounces; buyers, however, prefer not to handle lots of less than two ounces. For small lots settlement is usually made on the basis of recovered precious metals, each metal being paid for at the market price. Large lots are usually offered with an assay certificate from a reputable chemist. Sometimes sale is made on the basis of this assay, but more often on an adjustment of the seller's assay and an assay of a sample taken in the presence of the buyer. As the actual recoveries seldom equal the content shown by assay, some sales are made on a figure which is the average of the assay content and actual recovery. The latter method is not liked by sellers. As all crude platinum carries appreciable quantities of palladium and iridium, and some of the rare elements of the platinum group, as well as more or less gold and silver, all the precious metals are shown in the analysis and should be paid for by the purchaser.

"Formerly the markets were so limited that buyers were in a position to dictate more or less the price of crude, and it has been said that in the past crude-platinum producers were really at the mercy of the few refiners. More recently, however, more buyers have entered the field, and reports indicate that the seller's position is better.

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[1] Hill, J. M., The marketing of platinum: Eng. & Min. Jour.-Press, Vol. 114, pp. 718–719, Oct. 21, 1922.

Much of the dissatisfaction of sellers of domestic crude platinum seems to be due to lack of care on their part in cleaning the metal before trying to market it. Often large amounts of sand grains mixed with platinum particles necessarily reduce the value of the material to the refiner, and the returns from such shipments are not satisfactory to the producer.

"As the platinum metals are very heavy, the volume of a package containing several hundred ounces is not large. Adequate packing for shipment to prevent loss is very important. Shipments of large size from South America are often doubly wrapped in specially tough, semiglazed paper, sewn into tightly woven cotten cloth, which in turn is sewn into canvas and sealed. This package is placed in a box made of ⅞-inch boards to fit the parcel exactly, put together with screws, the heads of which are deeply countersunk and the holes above the screw head filled with sealing wax. For small shipments such elaborate packing is possibly not necessary, though every precaution against loss through breakage of the wrappings should be taken. Domestic platinum shipments are usually made either by insured parcel post, or express, the rate varying from one-half of 1 per cent to 1 per cent of the value. Insurance companies will insure shipments to and from foreign countries at a usual rate of one-half of 1 per cent, though some rates are lower.

"The market for platinum, both crude and refined metal, is very sensitive, and prices vary from day to day, depending more on the supply of imported material than demand, though sellers of crude platinum watch the market closely for sudden changes in price. The strongest market is usually in the fall, when manufacturing jewelers begin making up stock for the holidays, for the jewelry industry is the largest and most steady buyer of platinum. The following table gives the range of prices of the three principal platinum metals for the last ten years. Although prices have decreased considerably since the war, they are still much above the pre-war level, and it is believed that high prices will prevail for some years, for supplies of crude platinum are short and will be short until the Russian fields again become a factor in the market."

"Prices of the Three Important Platinum Metals, Per Troy Ounce, 1911–1921.

	Platinum	Palladium	Iridium
"1911	$43 50	$55 00	$62 00
1912	45 50	55 00	65 00
1913	44 88	50 00	65 00
1914	45 00	44 00	65 00
1915	55 00	56 00	83 00
1916	84 00	67 00	94 00
1917	103 00	110 00	150 00
1918	105 00	135 00	175 00
1919	123 00	130 00	255 00
1920	111 00	108 00	331 00
1921	75 00	59 00	195 00

"All dealings in the platinum metals are on a strictly cash basis, and no discounts are either asked or given. Though quotations are published each week, it is practically impossible to get a 'firm offer' either to buy or sell that holds for more than forty-eight hours. All transactions for both crude and refined metals are based on the troy ounce of 480 grains. As the domestic production of platinum metals is practically negligible, imports of foreign crude are absolutely necessary to supply our refiners, and, as there is a world shortage of crude platinum, it is necessary to import considerable quantities of refined metals. English, French, and German brands seem to be equally acceptable, possibly because they pass through the hands of domestic refiners and makers, whose reputation is established and concerning the character of whose goods there is no question. As a matter of fact, the ultimate consumer rarely knows whether he or she has real platinum or something of the same color. So long as the piece of jewelry or apparatus looks and acts as platinum should, there is little question as to the chemical purity of the metal."

A recent press bulletin[2] of the U. S. Geological Survey shows that the total consumption of platinum metals in the United States in 1922 was 181,498 troy ounces, an increase of about 3% as compared with the consumption in 1921.

[2]U. S. Geol. Surv., Press Bulletin, June 20, 1923.

"Consumption of Platinum in the United States, 1921–1922, by Industries, in Troy Ounces.

Industry	Platinum	Iridium	Palladium	Total	Per cent of total
1921					
"Chemical	12,273	34	45	12,352	7.02
Electrical	20,574	1,003	7,626	29,203	16.58
Dental	13,181	75	8,501	21,757	12.35
Jewelry	101,258	2,367	1,265	104,890	59.55
Miscellaneous	3,791	3,938	217	7,946	4.50
Totals	151,077	7,417	17,654	176,148	100.00
1922					
"Chemical	8,834	172	458	9,464	5.02
Electrical	24,988	1,537	2,735	29,260	16.12
Dental	11,651	83	5,535	17,269	9.71
Jewelry	108,527	2,588	9,852	120,967	66.65
Miscellaneous	2,838	1,064	636	4,538	2.50
Totals	156,838	5,444	19,216	181,498	100.00"

Platinum Production of California by Years.

The annual production and value since 1887, have been as follows:

Year	Ounces	Value	Year	Ounces	Value
1887	100	$400	1906	91	$1,647
1888	500	2,000	1907	300	6,255
1889	500	2,000	1908	706	13,414
1890	600	2,500	1909	416	10,400
1891	100	500	1910	337	8,386
1892	80	440	1911	521	14,873
1893	75	517	1912	603	19,731
1894	100	600	1913	368	17,738
1895	150	900	1914	463	14,816
1896	162	944	1915	667	21,149
1897	150	900	1916	886	42,642
1898	300	1,800	1917	610	43,719
1899	300	1,800	1918	571	42,788
1900	400	2,500	1919	*418	50,611
1901	250	3,200	1920	477	68,977
1902	39	468	1921	613	58,754
1903	70	1,052	1922	795	90,288
1904	123	1,849			
1905	200	3,320	Totals	13,025	$563,878

*Fine ounces, beginning with 1919.

QUICKSILVER.

Bibliography: State Mineralogist Reports IV, V, XII-XV, XVII, XVIII. Bulletins 27, 78, 91. U. S. Geol. Surv., Monograph XIII. U. S. Bur. of Mines, Tech. Papers 96, 227.

Quicksilver was produced in California in seven counties during 1922, to the amount of 3466 flasks, valued at $191,851, being a slight increase both in amount and value over the 1921 output, which was the smallest number of flasks produced in a year in California since the quicksilver industry began in 1849. The average price received during 1922, according to the producers' reports to the State Mining Bureau,

was $55.35 per flask, as against $44.56 in 1921, and the record average of $114.03 for the year 1918.

The average of San Francisco quotations for 1922 was $57.78 per flask. Quotations ranged from $47.30 in February to $71.30 at the close of the year.

Because of high operating costs, and foreign importations, practically all of California's important quicksilver producers have been shut down since November, 1920, with the exception of the Senator Mine of the New Almaden Company in Santa Clara County, which has been working steadily, and the Cloverdale Mine in Sonoma, operated intermittently. Operations are now being resumed at the New Idria Mine, San Benito County, and at the Oat Hill and the Knoxville mines, Napa County.

The tariff act of 1922 provides for an import duty of 25¢ per pound, or $18.75 per flask (75 pounds, net). This became effective September 21, 1922, following which the situation for our domestic producers has been somewhat improved.

Quicksilver, though not used in such quantities as is copper or some of the other metals, is not less vital in peace than in war. No completely successful substitute has yet been found for quicksilver in some of its uses. Except during the stimulated production resulting from the high prices of the war period, our domestic output of quicksilver for a number of years has not kept pace with domestic consumption. This is not due to a lack of local sources, but mainly to the competition of low-cost foreign metal dumped onto our market through an almost negligible import duty. Other financial and economic conditions obtaining during these years have also had their effect on the situation, but they could have been weathered had it not been that the lack of tariff protection permitted the too-free entry of foreign metal. There is plenty of ground, even in California, in addition to what may be in Nevada and Texas, that will warrant development if only a fair price can be assured that will justify exploitation.

Uses.

The most important uses of quicksilver are the recovery of gold and silver by amalgamation, and in the manufacture of fulminate for explosive caps, of drugs, of electric appliances, and of scientific apparatus. By far the greatest consumption is in the manufacture of fulminate and drugs.

One new use for quicksilver is in the introduction of a small amount into the cylinders of steam turbines to improve the vapor pressure and thus increase efficiency. This mercury is recoverable and can be re-used, so that there is only a small proportional loss.

Quicksilver is an absolutely essential element from a military standpoint, as there has not yet been produced an entirely satisfactory commercial substitute for it in the manufacture of fulminating caps for explosives. However, in order to reduce consumption of the fulminate, some potassium chlorate, picric acid, trinitro-toluol, or tetranitromethylamine is sometimes mixed with it.

Total Quicksilver Production of California.

Total amount and value of the quicksilver production of California, as given in available records, is shown in the following tabulation. Though the New Almaden Mine in Santa Clara County was first worked in 1824, and has been in practically continuous operation since 1846 (though the yield was small the first two years), there are no available data on the output earlier than 1850. Previous to June, 1904, a 'flask' of quicksilver contained 76½ pounds, but since that date 75 pounds. In compiling this table the following sources of information were used: for 1850–1883, table by J. B. Randol, in Report of State Mineralogist, IV, p. 336; 1883–1893, U. S. Geological Survey reports; 1894 to date, statistical bulletins of the State Mining Bureau; also State Mining Bureau, Bulletin 27, "Quicksilver Resources of California," 1908, p. 10:

Year	Flasks	Value	Average price per flask	Year	Flasks	Value	Average price per flask
1850	7,723	$768,052	$99 45	1887	33,760	1,430,749	$42 38
1851	27,779	1,859,248	66 93	1888	33,250	1,413,125	42 50
1852	20,000	1,166,600	58 33	1889	26,464	1,190,880	45 00
1853	22,284	1,235,648	55 45	1890	22,926	1,203,615	52 50
1854	30,004	1,663,722	55 45	1891	22,904	1,036,406	45 25
1855	33,000	1,767,150	53 55	1892	27,993	1,139,595	40 71
1856	30,000	1,549,500	51 65	1893	30,164	1,108,527	36 75
1857	28,204	1,374,381	48 73	1894	30,416	934,000	30 70
1858	31,000	1,482,730	47 83	1895	36,104	1,337,131	37 04
1859	13,000	820,690	63 13	1896	30,765	1,075,449	34 96
1860	10,000	535,500	53 55	1897	26,691	993,445	37 28
1861	35,000	1,471,750	42 05	1898	31,092	1,188,626	38 23
1862	42,000	1,526,700	36 35	1899	29,454	1,405,045	47 70
1863	40,531	1,705,544	42 08	1900	26,317	1,182,786	44 94
1864	47,489	2,179,745	45 90	1901	26,720	1,285,014	48 46
1865	53,000	2,432,700	45 90	1902	29,552	1,276,524	43 20
1866	46,550	2,473,202	53 13	1903	32,094	1,335,954	42 25
1867	47,000	2,157,300	45 90	1904	*28,876	1,086,323	37 62
1868	47,728	2,190,715	45 90	1905	24,655	886,081	35 94
1869	33,811	1,551,925	45 90	1906	19,516	712,334	36 50
1870	30,077	1,725,818	57 38	1907	17,379	663,178	38 16
1871	31,686	1,999,387	63 10	1908	18,039	763,520	42 33
1872	31,621	2,084,773	65 93	1909	16,217	773,788	47 71
1873	27,642	2,220,482	80 33	1910	17,665	799,002	45 23
1874	27,756	2,919,376	105 18	1911	19,109	879,205	46 01
1875	50,250	4,228,538	84 15	1912	20,600	866,024	42 04
1876	75,074	3,303,256	44 00	1913	15,661	630,042	40 23
1877	79,396	2,961,471	37 30	1914	11,373	557,846	49 05
1878	63,880	2,101,552	32 90	1915	14,199	1,157,449	81 52
1879	73,684	2,194,674	29 85	1916	21,427	2,003,425	93 50
1880	59,926	1,857,706	31 00	1917	24,382	2,396,466	98 29
1881	60,851	1,815,185	29 83	1918	22,621	2,579,472	114 03
1882	52,732	1,488,624	28 23	1919	15,200	1,353,381	89 04
1883	46,725	1,343,344	28 75	1920	10,278	775,527	75 45
1884	31,913	973,347	30 50	1921	3,157	140,666	44 56
1885	32,073	986,245	30 75	1922	3,466	191,851	55 35
1886	29,981	1,064,326	35 50	Totals	2,192,450	$107,033,457	

*Flasks of 75 lbs. since June, 1904; of 76½ lbs. previously.

SILVER.

Bibliography: State Mineralogist Reports IV, VIII, XII–XIX (inc.). Bulletins 67, 91. Min. & Sci. Press, March 1, 1919.

Silver in California is produced largely as a by-product from its association with copper, lead, zinc, and gold ores. As explained under the heading of Gold, the State Mining Bureau does not collect the statistics of silver production independently of the U. S. Geological Survey.

The average price of domestic silver during 1922 was $1.00 per ounce at New York as compared with 54.8¢ in 1914; 50.7¢ in 1915; 65.8¢ in 1916; 82.4¢ in 1917; $1 in 1918; $1.12 in 1919; $1.09 in 1920 and $1.00 in 1921.

The following paragraph is quoted from the U. S. Geological Survey Advance Chapter on 1922, by courtesy of Mr. J. M. Hill, statistician in charge of the San Francisco branch office:

"There were 3,100,065 ounces of silver produced in California in 1922, which is 529,158 ounces less than the output in 1921. This loss of silver output is largely due to the decreased shipments from the Randsburg district in San Bernardino County, for much more silver was produced from the lead ores of Inyo County and the copper ores of Plumas County than in 1921. The decrease in silver production from the Randsburg district was 835,754 ounces.

"The output of silver from placer mines in 1922 was 19,613 ounces, about 50 per cent as much as in 1921, and the decrease was practically all from the dredge operations, which produced 16,608 ounces in 1922, as compared with 36,322 ounces in 1921. There were slight increases of silver output from drift and hydraulic operations, but surface placers produced less silver than in 1921.

"The production of silver from deep mines was 3,080,452 ounces, a decrease of 510,141 ounces, as compared with 1921. The deep mines supplied 99.37 per cent of the silver output of the state. The Kelly mine at Randsburg was by far the largest producer of silver in the state and the production of silver from San Bernardino County was 77 per cent of the total deep mine output. The copper ores mined in Plumas County carried the second largest quantity, and the lead ores mined in Inyo County the third largest quantity of silver produced at deep mines. The output of silver from deep mines of these counties was 296,764 ounces and 256,009 ounces, respectively. The next nearest competitor was Amador County, whose dry gold ores yielded 32,039 ounces of silver. Dry silver ores mined in 1922 yielded 77 per cent, copper ores 10 per cent, lead ore 9 per cent, and dry gold ore 3 per cent of the total deep mine silver output of the state. Gold and silver mills recovered 3 per cent, concentrates produced at all types of mills carried 35 per cent, and ore sent direct to smelters 62 per cent of the silver output of California in 1922."

Silver output was sustained and encouraged through the operation of the Pittman Act maintaining the price of domestic silver at $1.00 per ounce minimum. This ceased, however, after June of the current year, 1923.

The distribution of the 1922 silver yield, by counties, was as follows:

County	Value	County	Value
Amador	$32,287	Plumas	297,254
Butte	1,890	Sacramento	3,392
Calaveras	11,648	San Bernardino	2,374,948
El Dorado	376	Shasta	26,901
Fresno	87	Sierra	14,484
Humboldt	10	Siskiyou	612
Imperial	18,024	Trinity	2,432
Inyo	256,009	Tuolumne	2,976
Kern	6,524	Yuba	8,222
Madera	3,500	Colusa, Del Norte, Lassen, Los Angeles, Orange, San Diego, Merced and Stanislaus*	2,967
Mariposa	3,301		
Mono	11,686		
Nevada	19,583		
Placer	952	Total value	$3,100,065

*Combined to conceal output of a single operator in each.

Silver Production of California by Years.

The value of the silver produced in California each year since 1880 has been as follows, the data previous to 1887 being taken from the reports of the Director of the Mint. There are no data available for the years previous to 1880:

Year	Value	Year	Value
1880	$1,140,556	1902	$616,412
1881	750,000	1903	517,444
1882	845,000	1904	873,525
1883	1,460,000	1905	678,494
1884	[1]4,185,101	1906	817,830
1885	2,568,036	1907	751,646
1886	1,610,626	1908	873,057
1887	1,632,004	1909	1,091,092
1888	1,700,000	1910	993,646
1889	1,065,281	1911	673,336
1890	1,060,613	1912	799,584
1891	953,157	1913	832,553
1892	463,602	1914	813,938
1893	537,158	1915	851,129
1894	297,332	1916	1,687,345
1895	599,790	1917	1,462,955
1896	422,464	1918	1,427,861
1897	452,789	1919	1,240,051
1898	414,055	1920	1,859,896
1899	504,012	1921	3,629,223
1900	[2]724,500	1922	3,100,065
1901	[2]571,849		
		Totals	$49,549,007

[1]Lawver, A. M., in Production of Precious Metals in United States: Report of Director of Mint, 1884, p. 175; 1885.
[2]Recalculated to 'commercial' from 'coining value,' as originally published.

TIN.

Bibliography: Reports XV, XVII, XVIII. Bulletins 67, 91.

Tin is not at present produced in California; but during 1891–1892, there was some output from a small deposit near Corona, in Riverside County, as tabulated below. Small quantities of stream tin have been found in some of the placer workings in northern California, but never in paying amounts.

Two occurrences have also been noted, in northern San Diego County. Crystals of cassiterite were found there, associated with blue tourmaline crystals, amblygonite and beryl. No commercial quantity has been developed, only small pockets having been taken out.

The principal sources of the world's supply of tin are the islands of Banka, Billiton and Singkep, Netherlands India (Dutch East Indies), followed by the Federated Malay States (Perak, Pahang, Negri Sembilan and Selangor). Bolivia, Siam, Cornwall, Transvaal, New South Wales, Queensland and Tasmania are also important sources. A measurable amount of the metal is also recovered by de-tinning scrap and old cans.

Total output of tin in California:

Year	Pounds	Value
1891	125,289	$27,561
1892	126,000	32,400
Totals	251,289	$59,961

TUNGSTEN.

Bibliography: Reports XV, XVII, XVIII. Bulletins 38, 67, 91. U. S. G. S. Bull. 652. Proc. Colo. Sci. Soc. Vol. XI. South Dakota School of Mines, Bulletin No. 12. Eng. and Min. Jour.-Press, Vol. 113, pp. 666–669. Apr. 22, 1922.

Tungsten ore has been produced in California principally in the Atolia-Randsburg district in San Bernardino and Kern counties, followed by the Bishop district in Inyo County, with small amounts coming from Nevada County and from the district near Goffs, in eastern San Bernardino. Most of the California tungsten ore is scheelite (calcium tungstate), though wolframite (iron-manganese tungstate) and hübnerite (manganese tungstate) also occur. The deposits at Atolia are the largest and most productive scheelite deposits known,[1] and the output has in some years equaled or exceeded that of ferberite (iron tungstate) from Boulder County, Colorado. It is interesting in this connection to note that, in practically all other tungsten producing districts of the world, wolframite is the important constituent. Burma, the largest producer, reported[2] for 1917–1919, yields of 4,537, 4,443, and 3,577 tons of wolframite concentrates, respectively, most of which was obtained from placers, in part associated with cassiterite (tin oxide).

Imports of foreign tungsten ores into the United States during 1922 amounted to 1665 long tons, valued at $281,251, compared with 1441 long tons at $276,757 in 1921, 1740 long tons, at $779,593, in 1920, 8400 long tons, at $6,261,190, in 1919, and 10,362 long tons valued at $11,409,237, in 1918, which ores were duty free up to September 22, 1922. Owing to lack of protection against the cheap coolie labor of Asiatic tungsten mines, and the low market prices, practically all of the tungsten mines in the United States have been closed down since the middle of 1919. Quotations during 1922 ranged around $2.50 per unit, up to September. Present quotations are $8.50–$9.00, with a minimum of 60%. The tariff act of 1922, which became effective September 22, 1922, placed a duty on tungsten ore or concentrates of 45¢ per pound on the metallic tungsten contained therein. Duties are also provided for imported tungsten-bearing alloys.

The value of the ore is based upon the content of tungstic trioxide (WO_3), and quotations are commonly made per unit (each 1%) of WO_3 present.

In California in 1920–1922, there was no production of tungsten, neither of ore nor concentrates, for the first time since the beginning of tungsten mining in this state. The tonnages here shown are recalculated

[1] U. S. G. S., Bull. 652, p. 32.
[2] U. S. Commerce Reports, No. 78, April 5, 1921, p. 95.

to a basis of 60% WO_3. Concentrates usually carry 59% to 63%. Previous to 1915, a single company produced almost all of California's tungsten. During the latter part of 1915, and the early months of 1916, because of the high prices prevailing, prospecting was much stimulated, and the known tungsten-bearing areas were considerably extended both in San Bernardino and Kern counties. In the Clark Mountain and New York Mountain districts in eastern San Bernardino County, wolframite and hübnerite are the principal ores, with some scheelite, while at Atolia it is scheelite only. Scheelite is also the tungsten mineral in Inyo County near Bishop, and three concentrating mills have been in operation there. The Nevada County ore is scheelite.

The metal, tungsten, is used mainly in the steel industry and in the manufacture of electrical appliances, including the well-known tungsten filament lamps. Because of its resistance to corrosion by acids, it is valuable in making certain forms of chemical apparatus. Its employment in tool-steel alloys, permits the operation of cutting tools, such as in lathe work, at a speed and temperature at which carbon steel would lose its temper—hence the name 'high speed' steels for these tungsten alloys. As made in the United States, tungsten forms 13% to 20% of such steels. Some chromium, nickel, cobalt, or vanadium, are sometimes also included. Tungsten compounds are used in the manufacture of colors.

Tungsten is introduced into the molten steel charge, either as the powdered metal or as ferro-tungsten (containing 50%–85% tungsten). The specific gravity of the pure metal, 19.3–21.4, is exceeded only by platinum, 21.5; iridium, 22.4; and osmium, 22.5. Its melting point is 3,267° C. (5,913° F.), being higher than any other known metal. Though millions of tungsten filament lamps are now made, the wires are so fine that the metal they contain represents but a few tons of tungsten concentrates annually.

Total Tungsten Ore Production of California.

The annual amount and value of tungsten ores and concentrates produced in California since the inception of the industry is given herewith, with tonnages recalculated to 60% WO_3:

Year	Tons at 60% WO_3	Value	Year	Tons at 60% WO_3	Value
1905	57	$18,800	1914	420	$180,575
1906	485	189,100	1915	962	1,005,467
1907	287	120,587	1916	2,270	4,571,521
1908	105	37,750	1917	2,466	3,079,013
1909	577	190,500	1918	1,982	2,832,222
1910	457	208,245	1919	214	219,316
1911	387	127,706	1920	----------	----------
1912	572	206,000			
1913	559	234,673	Totals	11,800	$13,221,475

VANADIUM.

Bibliography: Report XV. Bulletin 67. Proc. Colo. Sci. Soc., Vol. XI. U. S. Bur. of Mines, Bulletin 104.

No commercial production of vanadium has as yet been made in California. Occurrences of this metal have been found at Camp Signal, near Goffs, in San Bernardino County, and two companies at one time did considerable development work in the endeavor to open up paying

quantities. Each had a mill under construction in 1916, but apparently no commercial output was made. Ore carrying the mineral cuprodescloizite and reported as assaying 4% V_2O_5 was opened up. Late in 1917, some ore carrying lead vanadate was discovered in the 29 Palms, or Washington district, on the line between Riverside and San Bernardino counties.

The principal use of vanadium is as an alloy in steels, especially in tool steel and in those varieties where resistance to repeated strains is required. Present New York quotations for vanadium ore are @ 75¢–$1 per pound of contained V_2O_5 (guaranteed minimum of 18% V_2O_5).

ZINC.

Bibliography: State Mineralogist Reports XIV, XV, XVII, XVIII. Bulletins 38, 67, 91.

The production of zinc in California in 1922 amounted to 3,034,430 pounds, worth $172,963 at the average price of 5.7¢ quoted for the metal. This output represents mainly the metal contained in zinc oxide prepared at the plant of the Shasta Zinc and Copper Company. There was also some ore shipped from Inyo County to Colorado for smelting. The oxide was obtained directly from zinc-copper ore by roasting in the reverberatory, collecting in a bag-house, and subsequent refining. The resultant product was sold to paint and rubber manufacturers; and there appears to be a promising future for such business on the Pacific Coast. There are already several automobile tire plants in operation in California.

The zinc ores of Shasta and Calaveras counties are associated with copper, while those of Inyo and San Bernardino are associated principally with lead-silver and zinc-silver ores.

The principal uses of zinc are for 'galvanizing' (plating on iron to prevent rust), for zinc oxide (used in rubber goods and paint), and for brass (an alloy of copper and zinc). These outlets for the metal take approximately 80% of the quantity produced. Of the remaining 20% a large portion is rolled into plates and sheets, and utilized in the building industry for sheathing, roofing, leaders, and eaves-troughs. Zinc is particularly desirable and efficient for roofing and siding where corrosive gases are present, as at smelters, refineries and chemical plants.

Total Zinc Production of California.

Total figures for zinc output of the state are as follows, commercial production dating back only to 1906:

Year	Pounds	Value	Year	Pounds	Value
1906	206,000	$12,566	1915	13,043,411	$1,617,383
1907	177,759	10,598	1916	15,950,565	2,137,375
1908	54,000	3,544	1917	11,854,804	1,209,190
1909	----	----	1918	5,565,561	506,466
1910	----	----	1919	1,384,192	101,046
1911	2,679,842	152,751	1920	1,188,009	96,229
1912	4,331,391	298,866	1921	846,184	42,309
1913	1,157,947	64,845	1922	3,034,430	172,963
1914	399,641	20,381			
			Totals	61,873,736	$6,446,512

CHAPTER FOUR.

STRUCTURAL MATERIALS.

Bibliography: State Mineralogist Reports XIV, XV, XVII. Bulletin 38. See also under each substance.

As indicated by this subdivision heading, the mineral substances herein considered are those more or less directly used in building and structural work. California is independent, so far as these are concerned, and almost any reasonable construction can be made with materials produced in the state. This branch of the mineral industry for 1922 was valued at $36,992,001, as compared with a total value of $33,477,120 for the year 1921, the increase being due to continued activity in all building and construction operations which followed the release of war-time restrictions. In most cases in 1922, increased tonnages were sold, but at lower unit prices.

Deposits of granite, marble and other building stones are distributed widely throughout this state, and transportation and other facilities are gradually being extended so that the growing demand may be met. The largest single item, cement, has had an interesting record of growth since the inception of the industry in California about 1891. Not until 1904 did the annual value of cement produced reach the million-dollar mark, following which it increased 500% in nine years; though from 1914 to 1918 there was a falling off common to all building materials. The 1921 output established a new high-level mark, both in quantity and value. The quantity sold in 1922 was greater than in 1921, but the total value less, owing to drop in price.

Crushed rock production is yearly becoming more worthy of consideration, due to the strides recently taken in the use of concrete, as well as to activity in the building of good roads. Brick, with an average annual output for a number of years worth approximately $2,000,000, had difficulty in holding its own, due to the popularity of cement and concrete. In 1920, however, the sales increased to nearly double the previous record figure of the year 1907, with only a slight decrease in 1921; but 1922 showed an advance to new record figures. This item will, no doubt, continue to be an important one, and of course a market for fire and fancy brick of all kinds will never be lacking.

Fifty-five counties contributed to this structural total for 1922, and there is not a county in the state which is not capable of some output of at least one of the materials under this classification.

The following summary shows the value of the structural materials produced in California during the years 1921-1922, with increase or decrease in each instance.

Substance	1921		1922		Increase+ Decrease— Value
	Amount	Value	Amount	Value	
Bituminous rock	8,298 tons	$43,192	4,624 tons	$13,570	$29,622—
Brick and tile		5,570,875		7,994,991	2,424,116+
Cement	7,404,221 bbls.	18,072,120	8,962,135 bbls.	16,524,056	1,548,064—
Chromite	347 tons	6,870	379 tons	6,334	536—
Granite		725,901		676,643	49,258—
Lime	463,534 bbls.	610,619	578,748 bbls.	671,747	61,128+
Magnesite	47,837 tons	511,102	55,637 tons	594,665	83,563+
Marble	30,232 cu. ft.	98,395	38,321 cu. ft.	127,792	29,397+
Onyx	2,569 cu. ft.	1,294	10,950 cu. ft.	3,320	2,026+
Sandstone	10,150 cu. ft.	2,112	900 cu. ft.	1,100	1,012—
Slate			*	*	* +
Stone, miscellaneous		7,834,640		10,377,783	2,543,143+
Total values		$33,477,120		$36,992,001	
Net increase					$3,514,881+

*Concealed under 'Unapportioned.'

ASPHALT.

Bibliography: State Mineralogist Reports VII, X, XII-XV (inc.), XVII, XVIII. Bulletins 16, 32, 63, 67, 69, 91.

Asphalt was for a number of years accounted for in reports by the State Mining Bureau, because in the early days of the oil industry, considerable asphalt was produced from outcroppings of oil sand, and was a separate industry from the production of oil itself. However, at the present time most of the asphalt comes from the oil refineries, which produce a better and more uniform grade; hence, its value is not now included in the mineral total, as to do so would be in part a duplication of the crude petroleum figures. Such natural asphalt as is at present mined is in the form of bituminous sandstones, and is recorded under that designation.

BITUMINOUS ROCK.

Bibliography: State Mineralogist Reports XII, XIII, XV, XVII, XVIII.

The manufacture of asphalt at the oil refineries has almost eliminated the industry of mining bituminous rock, but small amounts of the latter are still used occasionally for road dressing. The production during 1922 from quarries in Santa Cruz and Santa Barbara counties was 4,624 tons, valued at $13,570, compared with 8,298 tons and $43,192 in 1921.

The following tabulation shows the total amount and value of bituminous rock quarried and sold in California, from the records compiled by the State Mining Bureau, annually since 1887:

Year	Tons	Value	Year	Tons	Value
1887	36,000	$160,000	1906	16,077	$45,204
1888	50,000	257,000	1907	24,122	72,835
1889	40,000	170,000	1908	30,718	109,818
1890	40,000	170,000	1909	34,123	116,436
1891	39,962	154,164	1910	87,547	165,711
1892	24,000	72,000	1911	75,125	117,279
1893	32,000	192,036	1912	44,073	87,467
1894	31,214	115,193	1913	37,541	78,479
1895	38,921	121,586	1914	66,119	166,618
1896	49,456	122,500	1915	17,789	61,468
1897	45,470	128,173	1916	19,449	66,561
1898	46,836	137,575	1917	5,590	18,580
1899	40,321	116,097	1918	2,561	9,067
1900	25,306	71,495	1919	4,614	18,537
1901	24,052	66,354	1920	5,450	27,825
1902	33,490	43,411	1921	8,298	43,192
1903	21,944	53,106	1922	4,624	13,570
1904	45,280	175,680			
1905	24,753	60,436	Totals	1,172,825	$3,605,453

BRICK and TILE.

Bibliography: State Mineralogist Reports VIII, X, XII–XV (inc.), XVII, XVIII. Bulletin 38. Preliminary Report, No. 7.

Bricks of many varieties and in important quantities are annually produced in California, as might be expected in a state with such diversified and widespread mineral resources. The varieties include common, fire, pressed, glazed, enamel, fancy, vitrified, and others. So far as possible, the different kinds have been segregated in the tabulation herewith accompanying.

We also include under this heading the various forms of hollow building 'tile' or blocks. The application of these tile to residence construction as well as to other structures is growing; and their total value for 1922 shows a 50% increase over that for 1921.

The aggregate value for all kinds of brick in 1922 shows an increase of more than 40% over the 1921 output. Individually, the various groups (except fire brick, which decreased slightly) made material advances, and especially common brick which increased from $2,880.124 in 1921 to $4,363,629 in 1922. The total sales of common brick in Los Angeles County alone in 1922 (217,750 M valued at $2,990,151) exceeded the entire state's total of common for 1921 (202,417 M and $2,880,124). This item, of itself, is an indication of the activity in construction operations during the past year.

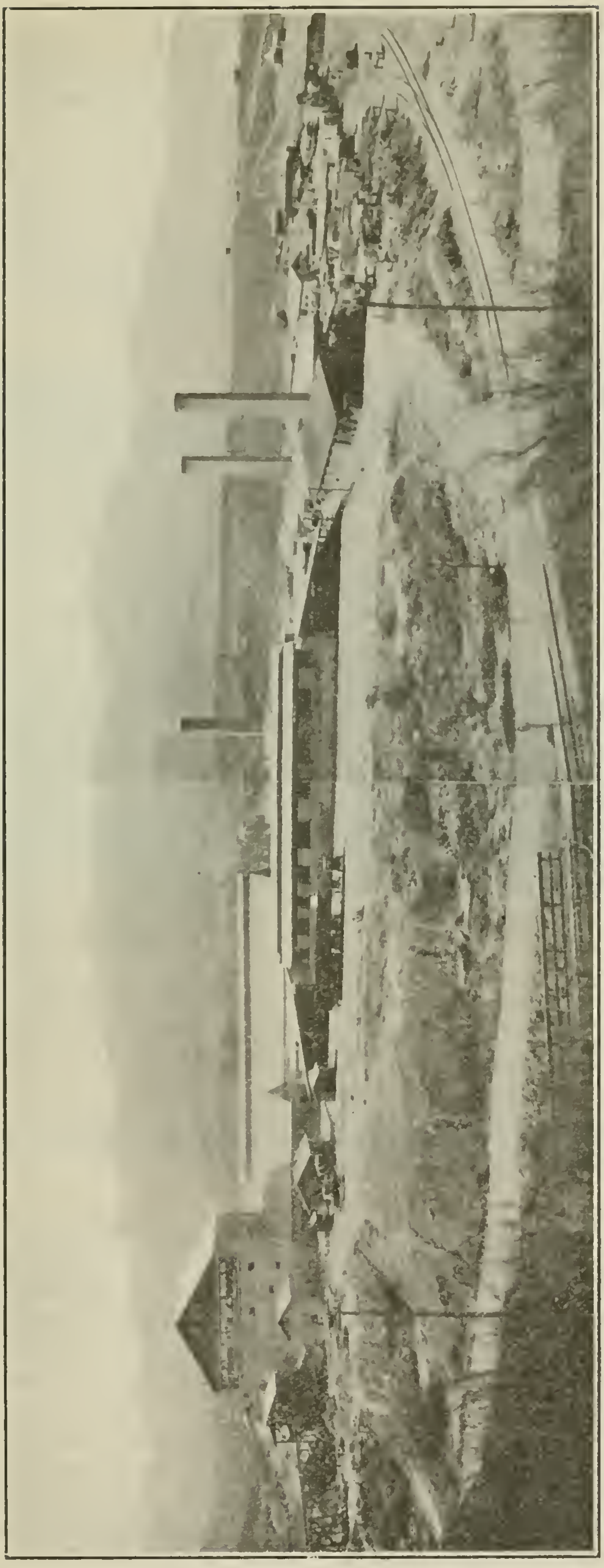
The detailed figures of brick and tile production for 1922, by counties, are given in the following tabulation. 'Production' in this case means *sales* of product of California manufacture; and 'value' is *net price* at the works, f.o.b. cars, trucks, or boats.

The detailed figures of brick and tile producton for 1922, by counties, are shown in the following tabulation:

BRICK AND TILE PRODUCTION FOR 1922, BY COUNTIES.

County	Common		Fire		Glazed, pressed, fancy, vitrified, paving		Hollow building tile or blocks		Total value
	Amount, M	Value	Amount, M	Value	Amount, M	Value	Tons	Value	
Alameda	*		1,997	$127,810	4,566	$193,217	31,617	$342,990	$661,017
Contra Costa	11,537	$138,624	*		*		*		138,624
Fresno	13,893	190,288	*		*		2,743	27,431	217,719
Kern	5,082	66,652							66,652
Los Angeles	217,750	2,990,151	7,832	395,599	14,842	804,735	39,095	397,136	4,587,621
Orange	4,706	73,106							73,106
San Diego	5,250	60,500					*		60,500
San Joaquin	8,675	112,242	*						112,242
Santa Clara	11,409	150,057							150,057
Alameda, Humboldt, Imperial, Lassen, Marin, Mendocino, Riverside, Sacramento, Santa Barbara, Tehama, Tulare*	45,318	582,000							
Amador, Contra Costa, Fresno, Placer, Riverside, Sacramento, San Joaquin*			14,183	637,526					
Contra Costa, Fresno, Placer, Riverside, Sacramento*					7,808	349,467			
Contra Costa, Merced, Placer, Riverside, Sacramento, San Diego, Tulare*							32,454	355,451	1,924,453
Totals	323,625	$4,363,629	24,012	$1,160,935	27,216	$1,347,419	105,9[illegible]9	$1,123,008	$7,994,991

*Combined to conceal output of a single operator in each.



Plant No. 4 of Los Angeles Pressed Brick Co., at Alberhill, Riverside County.

Brick and Tile Production of California, by Years.

Record of brick production in the state has been kept since 1893 by this Bureau, the figures for building tile being also included since 1914. The annual and total figures, for amount and value, are given in the following table:

Year	Brick, M	Building blocks, tons	Value
1893	103,900	------------	$801,750
1894	81,675	------------	457,125
1895	131,772	------------	672,360
1896	24,000	------------	524,740
1897	97,468	------------	563,240
1898	100,102	------------	571,362
1899	125,950	------------	754,730
1900	137,191	------------	905,210
1901	130,766	------------	860,488
1902	169,851	------------	1,306,215
1903	214,403	------------	1,999,546
1904	281,750	------------	1,994,740
1905	286,618	------------	2,273,786
1906	277,762	------------	2,538,848
1907	362,167	------------	3,438,951
1908	332,872	------------	2,506,495
1909	333,846	------------	3,059,929
1910	340,883	------------	2,934,731
1911	327,474	------------	2,638,121
1912	337,233	------------	2,940,290
1913	358,754	------------	2,915,350
1914	270,791	------------	2,288,227
1915	180,538	------------	1,678,756
1916	206,960	------------	2,096,570
1917	192,269	29,348	2,532,721
1918	136,374	34,818	2,363,481
1919	156,328	36,026	3,087,067
1920	245,842	99,208	5,704,393
1921	238,022	67,100	5,570,875
1922	374,853	105,909	7,994,991
Totals	6,558,414	372,409	$69,975,088

CEMENT.

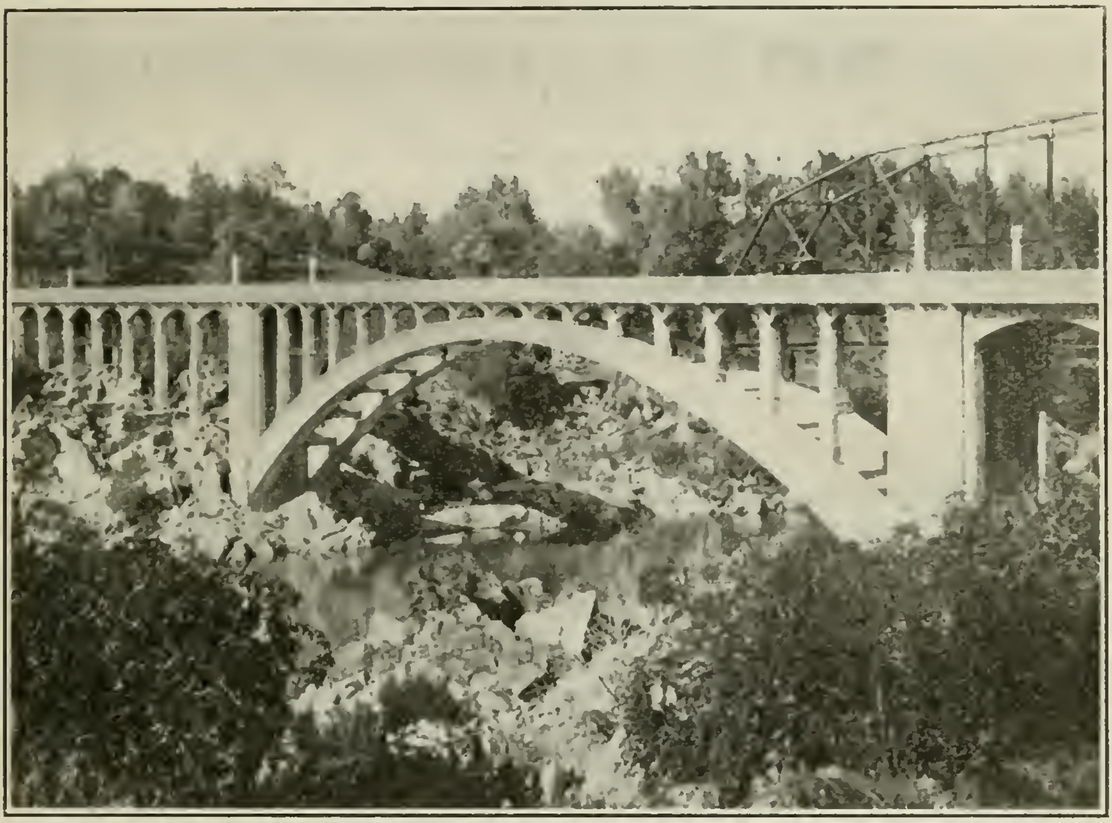
Bibliography: State Mineralogist Reports VIII, IX, XII, XIV, XV, XVII, XVIII. Bulletin 38.

Cement is the most important single structural material in the output of the state. During 1922, there was produced a total of 8,962,135 barrels, valued at $16,524,056, being an increase in quantity but a slight decrease in value from the record figures of 1921. As in the preceding year, the output came from nine operating plants in seven counties. The average value, reported, decreased from $2.44 per barrel in 1921, to $1.84 in 1922.

The cement industry is so distributed in California that it is not possible to apportion the details of production to the counties in which the plants are located without making private business public. With the exception of San Bernardino, no county has more than one cement plant. The three operating plants in San Bernardino County, in 1922,

made a total of 2,770,953 barrels of cement, valued at $4,156,430; the balance coming from a single plant in each of the following counties: Contra Costa, Kern, Riverside, San Benito, Santa Cruz and Solano.

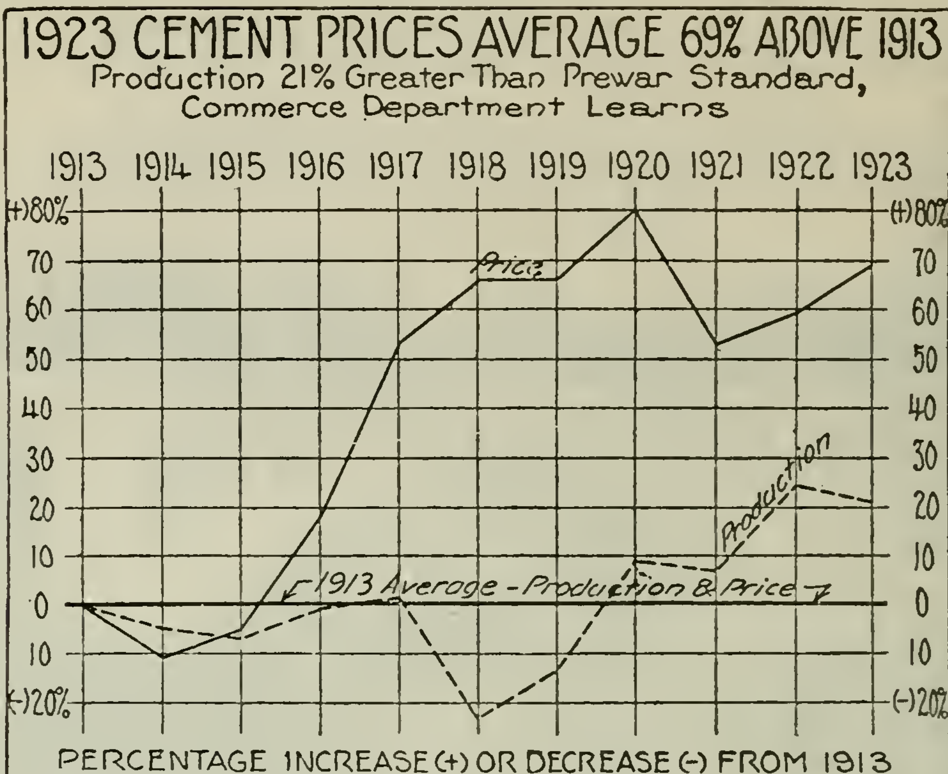
'Portland' cement was first commercially produced in California in 1891; though in 1860 and for several years following, a natural hydraulic cement from Benicia was utilized in building operations in



Reinforced concrete bridge over American River at Folsom, Sacramento County, California. Old steel bridge in background.

San Francisco. The growth of the industry became rapid after 1902; since which time cement has continued to be an important factor in the industrial life of the state. Although the total cement figures, to date, are not of the same magnitude as those for gold and petroleum, it is interesting to note that the value of California's cement yield beginning with 1920 has since annually exceeded the value of her gold output.

According to reports of the U. S. Geological Survey, California ranks third as a cement producer, being surpassed by Pennsylvania and Indiana.



Monthly Averages	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923*
Price	-11	-6	+18	+53	+66	+66	+80	+53	+59	+69
Production	-4	-7	-1	+1	-23	-13	+9	+7	+24	+21

* First Four Months

Cement Production of California by Years.

Annual production of cement in California has been as follows:

Year	Barrels	Value	Year	Barrels	Value
1891	5,000	$15,000	1908	1,629,615	$2,359,692
1892	5,000	15,000	1909	3,779,205	4,969,437
1893			1910	5,453,193	7,485,715
1894	8,000	21,600	1911	6,371,369	9,085,625
1895	16,383	32,556	1912	6,198,634	6,074,661
1896	9,500	28,250	1913	6,167,806	7,743,024
1897	18,000	66,000	1914	5,109,218	6,558,148
1898	50,000	150,000	1915	4,918,275	6,044,950
1899	60,000	180,000	1916	5,299,507	6,210,293
1900	52,000	121,000	1917	5,790,734	7,544,282
1901	71,800	159,842	1918	4,772,921	7,969,909
1902	171,000	423,600	1919	4,645,289	8,591,990
1903	640,868	968,727	1920	6,709,160	14,962,945
1904	969,538	1,539,807	1921	7,404,221	18,072,120
1905	1,265,553	1,791,916	1922	8,962,135	16,524,056
1906	1,286,000	1,941,250			
1907	1,613,563	2,585,577	Totals	89,453,487	$140,236,962

CHROMITE.

Bibliography: State Mineralogist Reports IV, XII, XIII, XIV, XV, XVII, XVIII. Bulletins 38, 76, 91. Preliminary Report 3 U. S. G. S., Bull. 430. Min. & Sci. Press, Vol. 114, p. 552.

Chromic iron ore, or chromite, to the amount of 312 short tons of all grades (or 379 tons, recalculated to a basis of 45% Cr_2O_3), valued at \$6,334 f. o. b. shipping point was sold in California during the year 1922. As in 1921, there were but three producers who reported sales last year, compared with the high mark of 236 in 1918, since which year the number has steadily decreased, owing to importations of foreign ore which can be landed at the consuming centers cheaper. The ore shipped in 1922 analyzed from 50.4% to 55% Cr_2O_3, and brought from \$18 to \$26.50 per ton. The principal production was in Placer County, and a small amount also from San Luis Obispo County and was utilized both for refractory and for chemical purposes.

Occurrence.

Until 1916, when some shipments were made from Oregon and smaller amounts from Maryland, Wyoming and Washington, practically our only domestic production of chromite for many years came from California. From 1820 to 1860 the deposits in Pennsylvania and Maryland supplied the world's consumption.

Chromite is widely distributed in California, the principal production, thus far, having come from El Dorado, San Luis Obispo, Del Norte, Shasta, Siskiyou, Placer, Fresno, and Tuolumne counties. In 1918 a total of 29 counties contributed to the state's output. There are two main belts in California yielding this mineral, one along the Coast Ranges from San Luis Obispo County to the Oregon line, including the Klamath Mountains at the north end, and the other in the Sierra Nevada from Tulare County to Plumas County. Chromite occurs as lenses in basic igneous rocks such as peridotite and pyroxenite, and in serpentines which have been derived by alteration of such basic rocks. For the most part, so far as developments have yet shown, the lenses have proved to be small, relatively few of them yielding over 100 tons apiece. A notable exception to this was the deposit on Little Castle Creek, near Dunsmuir, from which upwards of 15,000 tons was shipped before it was exhausted. Deposits worked in Del Norte County during 1918 promised well for a large tonnage. On the whole the orebodies in the northwestern corner of the state appear to average larger in size than the chromite lenses in other parts of California.

Concentration became an accomplished fact in several localities, thus utilizing some of the disseminated and lower-grade orebodies which have been found. In fact, an important part of the 1918–1920 production came from that source.

Economic Conditions.

Chromite is one of several of California's minerals most affected by the economic conditions brought about by the European war. The

major portion of our domestic requirements for chrome is for consumption in the steel mills of the East. Formerly, most of that used was imported from Rhodesia and New Caledonia, and they are still, with the addition of India, the more important sources. The reports of the U. S. Department of Commerce show the foreign imports of chromic iron for the nine years 1913–1922, inclusive, to have been 49,772; 75,455; 115,886; 72,063; 100,142; 61,404; 150, 275; 81,836 and 90,081 long tons, respectively. The average price of imports in 1922 was $8.23 per ton.

The major consumption of chromic ore is for use as a refractory lining in smelting furnaces for steel and copper. A smaller portion is used in the preparation of ferro-chrome for chrome-steel alloys. Some of the California product in 1916–1918 was converted into ferrochrome in the electric furnaces of the Noble Electric Steel Company at Heroult, California, and some of it was similarly reduced in electric furnaces at Niagara Falls, New York. A small amount of high-grade ore is utilized in preparation of chromates for tanning.

Total Chromite Production of California.

Production of chromite in California began, apparently, about 1874, principally in San Luis Obispo County. There was considerable activity from 1880 to 1883, inclusive, and a total of 23,238 long tons (or 26,028 short tons), valued at $329,924 was shipped from that county up to the beginning of 1887. Some ore also was shipped from the Tyson properties in Del Norte County. The tabulation herewith shows the output of chromite in California, annually, including the earliest figures so far as they are available. The figures from 1887 to date are from the records of the State Mining Bureau:

Year	Tons	Value	Year	Tons	Value
1874–1886 (San Luis Obispo Co.)	26,028	$329,924	1905	40	$600
1887	3,000	40,000	1906	317	2,859
1888	1,500	20,000	1907	302	6,040
1889	2,000	30,000	1908	350	6,195
1890	3,599	53,985	1909	436	5,309
1891	1,372	20,580	1910	749	9,707
1892	1,500	22,500	1911	935	14,197
1893	3,319	49,785	1912	1,270	11,260
1894	3,680	39,980	1913	1,180	12,700
1895	1,740	16,795	1914	1,517	9,434
1896	786	7,775	1915	3,725	38,044
1897	----------	----------	1916	48,943	717,244
1898	----------	----------	1917	52,379	1,130,298
1899	----------	----------	1918	73,955	3,649,497
1900	140	1,400	1919	*4,314	97,164
1901	130	1,950	1920	1,770	43,031
1902	315	4,725	1921	347	6,870
1903	150	2,250	1922	379	6,334
1904	123	1,845	Totals	242,290	$6,410,827

*Recalculated to 45 per cent Cr_2O_3, beginning with 1919.

GRANITE.

Bibliography: State Mineralogist Reports X, XII–XVIII (inc.), Bulletin 38.

In the statistical reports of the State Mining Bureau for several years previous to 1916, granite was recorded as a subdivision under 'Stone Industry' or under 'Miscellaneous Stone.' Since 1916, we have given it a separate heading, as has always been done with marble and sandstone. Crushed rock, rubble, and paving blocks derived from granite quarries are continued under the heading of 'Miscellaneous Stone.'

The value of the granite output for 1921 was the highest of any year since 1892 with the exception of the year 1913, and was in part due to the resumption of building construction following the war-time curtailment, and in part due to the higher unit prices received for the 1921 product. For 1922 there was a slight decrease in total value, although there was a small increase in the quantity of building stone shipped but at lower unit values.

So far as possible, granite production has been segregated in the following table into the various uses to which the product was put. It will be noted, however, that a portion of the output has been entered under the heading 'unclassified.' This is necessary because of the fact that some of the producers have no way of telling to what specific use their stone was put after they had quarried and sold the same in the rough.

Varieties.

For building purposes, the granites found in California, particularly the varieties from Raymond in Madera County, Rocklin in Placer County, and near Porterville in Tulare County, are unexcelled by any similar stone found elsewhere. The quantities available, notably at Raymond and Porterville, are unlimited. Most of California's 'granite,' particularly that found in the Sierra Nevada Mountains, is technically 'granodiorite' (that is, both plagioclase and orthoclase feldspars are present).

Granites of excellent quality for building and ornamental purposes are also quarried in Riverside and San Diego counties. Near Lakeside, San Diego County, the McGilvray-Raymond Granite Company of San Francisco has taken over and enlarged operations at the quarry formerly worked by the Simpson-Pirnie Company. This is a fine-grained, 'silver-gray' granite of uniform texture and color, especially suited for monumental and ornamental work.

The Fresno County stone is a dark, hornblende diorite, locally called 'black granite,' whose color permits of a fine contrast of polished and unpolished surfaces, making it particularly suitable for monumental and decorative purposes. There is also a similar 'black granite' in Tulare County, near Success.

GRANITE PRODUCTION BY COUNTIES, FOR 1922.

County	Building stone		Monumental		Curbing		Unclassified		Total value
	Cubic feet	Value	Cubic feet	Value	Linear feet	Value	Cubic feet	Value	
Fresno			9,700	$28,200			*		$28,200
Madera	175,052	$295,323	29,108	113,491	*		22,264	$44,428	453,242
Placer	2,144	4,623	2,236	8,357					12,980
Riverside	10,296	20,608	2,798	7,752			5,200	1,850	30,210
Sacramento	8,000	30,000	128	2,500			[c]7,000	19,000	51,500
San Diego	285	641	15,646	35,032					35,673
Inyo,[a] Napa,[b] Tulare*	21,010	21,625							21,625
Nevada, Plumas, Tuolumne*			2,315	9,500					9,500
Madera, Nevada, Tuolumne*					1,455	2,776			2,776
Fresno, Tulare*							10,558	30,937	30,937
Totals	216,787	$372,820	61,931	$204,832	1,455	$2,776	45,022	$96,215	$676,643

*Combined to conceal output of a single operator in each.
[a]Tuff used for building stone.
[b]Red, volcanic stone used for building walls.
[c]Includes flagging.

Granite Production of California, by years.

The value of granite produced, annually, since 1887, has been as follows:

Year	Value	Year	Value
1887	$150,000	1906	$344,083
1888	57,000	1907	373,376
1889	1,329,018	1908	512,923
1890	1,200,000	1909	376,834
1891	1,300,000	1910	417,898
1892	1,000,000	1911	355,742
1893	531,322	1912	362,975
1894	228,816	1913	981,277
1895	224,329	1914	628,786
1896	201,004	1915	227,928
1897	188,024	1916	535,339
1898	147,732	1917	221,997
1899	141,070	1918	139,861
1900	295,772	1919	220,743
1901	519,285	1920	495,732
1902	255,239	1921	725,901
1903	678,670	1922	676,643
1904	467,472		
1905	353,837	Total	$16,866,628

LIME.

Bibliography: Reports XIV, XV, XVII, XVIII. Bulletin 38.

Lime to the amount of 578,748 barrels, valued at $671,747, was produced by seven plants in five counties during 1922, as compared with 463,534 barrels, valued at $610,619 in 1921. There were two plants, each, in Kern, San Bernardino, and Santa Cruz counties, and one in Tuolumne County.

So far as we have been able to segregate the data, these figures include only such lime as is used in building operations. A portion is hydrated lime. Limestone utilized in sugar making, for smelter flux, as a fertilizer, and other special industrial uses, are classified under 'Industrial Materials.' That consumed in cement manufacture is included in the value of cement.

Lime Production of California by Years.

The following tabulation gives the amounts and value of lime produced in California by years since 1894 when compilation of such records was begun by the State Mining Bureau:

Year	Barrels	Value	Year	Barrels	Value
1894	373,500	$318,700	1909	520,752	577,824
1895	397,764	386,094	1910	479,507	477,683
1896	302,750	261,505	1911	429,587	390,988
1897	287,800	252,900	1912	522,118	464,440
1898	297,860	254,010	1913	613,444	528,547
1899	299,854	314,575	1914	439,961	378,663
1900	312,517	283,699	1915	356,534	286,304
1901	317,383	334,688	1916	493,635	390,475
1902	448,664	369,616	1917	500,730	311,380
1903	493,587	418,280	1918	436,843	461,315
1904	579,451	571,749	1919	420,696	552,043
1905	616,995	555,322	1920	463,144	557,232
1906	689,268	763,060	1921	463,534	610,619
1907	684,218	756,376	1922	578,748	671,747
1908	396,386	379,243			
			Totals	13,220,230	$12,879,077

MAGNESITE.

Bibliography: State Mineralogist Reports XII, XIII, XIV, XV, XVII. Bulletin 38. U. S. G. S., Bulletins 355, 540; Min. Res. 1913, Pt. II, pp. 450–453. Min. & Sci. Press, Vol. 114, p. 237. "Magnesite"—Hearings before the Comm. on Ways and Means, House of Repr., on H. R. 5218, June 16, 17 and July 17, 1919. Eng. Soc. W. Penn., Proc. 1913, Vol. 29, pp. 305–388, 418–444. Eng. & Min. Jour.-Press, Vol. 114, July 29, and Dec. 2, 1922.

Occurrence.

Magnesite is a natural carbonate of magnesium, and when pure contains 52.4% CO_2 (carbon dioxide) and 47.6% MgO (magnesia). It has a hardness of 3.5 to 4.5, and specific gravity of 3 to 3.12. It is both harder and heavier than calcite (calcium carbonate), and also contains a higher percentage of CO_2, as calcite has but 44%.

Most of the California magnesite is comparatively pure, and is ordinarily a beautiful, white, fine-grained rock with a conchoidal fracture resembling a break in porcelain. The Grecian magnesite is largely of this character; but the Austrian varieties usually contain iron, so that they become brown after calcining. The Washington magnesite resembles dolomite and some crystalline limestones in physical appearance. Its color varies through light to dark gray, and pink.

In California the known deposits are mostly in the metamorphic rocks of the Coast Ranges and Sierra Nevada Mountains, being associated with serpentine areas. The notable exceptions are the sedimentary deposits, at Bissell in Kern County and at Afton in San Bernardino County. Several thousand tons have been shipped from the Bissell deposit; and small shipments have been made from the Afton property.

The Washington deposits are associated with extensive strata of dolomitic limestone. The magnesite there appears to contain more iron than most of the California mineral, which makes it desirable for the steel operators. However, recent experience has proved that several California localities have sufficient iron in their magnesite to be serviceable in the steel furnaces. This is particularly true of the Refractory Magnesite Company's mine near Preston in Sonoma County, the White Rock Mine at Pope Valley and the Blanco Mine in Chiles Valley, Napa County. There is some also at the Sampson Peak property in San Benito County.

Uses.

The principal uses include: Refractory linings for basic open-hearth steel furnaces, copper reverberatories and converters, bullion and other metallurgical furnaces; in the manufacture of paper from wood pulp; and in structural work, for exterior stucco, for flooring, wainscoting, tiling, sanitary kitchen and hospital finishing, etc. In connection with building work it has proved particularly efficient as a flooring for steel railroad coaches, on account of having greater elasticity and resilience than 'Portland' cement. For refractory purposes the magnesite is 'dead burned'—*i. e.*, all or practically all of the CO_2 is expelled from it. For cement purposes it is left 'caustic'—*i. e.*, from 2% to 10% of CO_2 is retained. When dry caustic magnesite is mixed with a solution of magnesium chloride ($MgCl_2$) in proper proportions, a very strong

cement is produced, known as oxychloride or Sorel cement. It is applied in a plastic form, which sets in a few hours as a tough, seamless surface. It has also a very strong bonding power, and will hold firmly to wood, metal, or concrete as a base. It may be finished with a very smooth, even surface, which will take a good wax or oil polish. As ordinarily mixed there is added a certain proportion of wood flour, cork, asbestos, or other filler, thereby adding to the elastic properties of the finished product. Its surface is described as 'warm' and 'quiet' as a result of the elastic and nonconducting character of the composite material. The cement is frequently colored by the addition of some mineral pigment to the materials before mixing as cement.

The desirable qualities of any flooring material (cost not considered) are listed for purposes of analysis or comparison under eighteen heads, as follows: Cleanliness (sanitary qualities), quietness, immunity from abrasion (surface wear), resilience, immunity from slipperiness, appearance, waterproof character, plasticity, warmth (thermal insulation), life (immunity from deterioration with age), acid-proof character, alkali-proof character, fire resistance, elasticity, crushing strength, structural strength (rupture), immunity from expansion and contraction, and lightness. The importance of these several qualities varies with the varying requirements to be met; for instance, in some places, as in hospitals, cleanliness is one of the prime considerations; in other places immunity from abrasion might be one of the principal requisites. As to most of these qualities the conclusion is reached that the magnesia cement affords one of the most satisfactory flooring materials for many purposes, such as in kitchen, laundry, toilet and bathrooms, corridors, large rooms or halls in public or other buildings, including hospitals, factories, shops and restaurants.

There is no doubt that the material is steadily coming into more general recognition and favor for these uses. For a few special uses it is more or less disqualified; as an instance, it is not suited for construction of swimming tanks or for conditions of permanent wetness, since under constant immersion it gradually softens, although it is said to withstand intermittent wetting and drying and is recommended for shower baths. Naturally it is not acid-proof and not wholly alkali-proof, which might be a disadvantage in use for laboratory floors and tables; but these are rather special requirements. Its cost per square foot is given (in 1913) as 25 to 33 cents, depending on area, which is estimated to be lower than marble, cork, rubber, clay or mosaic tile, slate or terrazzo, although more expensive than wood, asphalt, linoleum or Portland cement.

In the discussion of the subject (see Bibliography) the causes of failure are ascribed to uncertain climatic changes, lack of uniformity in the mixtures used, lack of care on the part of those handling the materials, possible deterioration of materials used through exposure (either before or after mixing), lack of proper preparation of foundations on which the material is to be laid, and, as a very important factor, experience or nonexperience in the manipulation or actual laying and troweling of the material. Data concerning the percentages of magnesium chloride and of ground calcined magnesia and data concerning the character and quantity of filler and color added to the commercial preparations are naturally guarded as trade secrets by the firms already in the

business. The examination and standardization of the raw materials used, and of acceptable filler materials, and the establishment of standard proportions for the mixtures would seem to be about the only satisfactory way of attacking the problem.

The condition of the calcination of magnesite for cement uses is important, as the same material may undoubtedly be greatly varied in its reacting properties by differing treatment in the kiln. It is generally agreed that the magnesite for cement use must be comparatively free from lime, as lime has a greater tendency to reabsorb water and carbon dioxide than the magnesia, thereby causing swelling, and is therefore not so permanent in the completed cement as a pure magnesia material. The fillers used may constitute 10% to 40% of the whole cement, and commonly consist of ground marble, sand, sawdust, cork, asbestos or other materials. As an example of the formulas used in mixing such cements the following are quoted:[1]

Mixtures for the underlying or coarser layer.

[Parts by weight.]

1. 15 parts magnesia.
   10 parts magnesium chloride solution, 20° Baumé.
   10 parts moist sawdust.
   (Sets in 36 hours.)

2. 10 parts magnesia.
   10 parts magnesium chloride solution, 28° Baumé.
   5 parts sawdust.
   (Sets in 16 hours.)

3. 20 parts magnesia.
   15 parts magnesium chloride solution, 20° Baumé.
   4 parts ground cork.
   (Sets in 24 hours.)

4. 5 parts magnesia.
   3 parts magnesium chloride solution, 20° Baumé.
   5 parts ashes.
   (Sets in 24 hours.)

Mixtures for overlying or surface layers.

[Parts by weight.]

1. 40 parts magnesia.
   33 parts magnesium chloride solution, 19° Baumé.
   10 parts asbestos powder.
   5 parts wood flour.
   1 part red ocher.
   (Sets in 24 hours.)

2. 25 parts magnesia.
   25 parts magnesium chloride, 21° Baumé.
   4½ parts wood flour, impregnated with 4½ parts Terpentinharzlösung.
   15 parts yellow ocher.
   (Sets in 30 hours.)

The magnesite used is the fine-ground calcined (not dead-burned) of certain specified kinds or place of derivation regularly sold for

[1]Scherer, Robert—Der Magnesit, sein Vorkommen, seine Gewinnung und technische Verwertung, pp. 216–217, A. Hartleben's Bibliothek, Wien und Leipzig, 1908.

plastic purposes. This material commonly comes in paper-lined casks, barrels or boxes, in which form it is fairly permanent, but it deteriorates by exposure, absorbing carbonic acid and moisture from the air. If carefully handled it can probably be kept unopened a year or more, but it should be used within a few weeks after being opened, even under most favorable conditions.

The use of magnesia cement has been suggested as a protecting coating for mine timbers, particularly against the fire hazard. The necessary qualities for any substance for such purpose have been summarized as follows: It should be resistant to abrasion, and to impact and structural stresses. It should be durable when subjected to the action of the elements, and stable to any minor derangements of the base on which it is placed. It must be relatively unaffected by changes in temperature, by the action of water, and should adhere to the material on which is it placed, and it should also be free from shrinkage cracks due to setting up the material, and have the ability to resist fire. Magnesite cement appears to fulfill the various conditions thus outlined.

It is stated that some metallic magnesium has been prepared electrolytically at Niagara Falls from magnesite.

For refractory purposes the calcined magnesite is largely made up into bricks, similar to fire-brick for furnace linings. It is also used unconsolidated, as 'grain' magnesite. For such, an iron content is desirable, as it allows of a slight sintering in forming the brick. Dead-burned, pure, magnesia can not be sintered except at very high temperatures; and it has little or no plasticity, so that it is hard to handle. Its plasticity is said to be improved by using with it some partly calcined or caustic magnesite. Heavy pressure will bind the material sufficiently to allow it to be sintered.

A coating of crushed magnesite is laid on hearths used for heating steel stock for rolling, to prevent the scale formed from attacking the fire-brick of the hearth.

Imports and Domestic Production.

Reports of the U. S. Bureau of Foreign and Domestic Commerce show imports of calcined magnesite to have been 172,591 long tons in 1913; 144,747 in 1914, and 63,347 in 1915; most of it coming from Austria-Hungary and some from Greece. For the same years the production of crude (from 2 to $2\frac{1}{2}$ tons of crude ore required to yield one ton of the calcined) magnesite in California (the sole producer of those years, in the United States) was: 9632 short tons, 11,438 tons, 30,721 tons, respectively. For 1916 the California output leaped to 154,052 tons of crude and to 209,648 tons in 1917, but has dropped considerably since then on account of resumption of foreign importations, which totaled 52,483 long tons in 1921, valued at $776,384, being then admitted duty free. Shipments from Washington were begun late in 1916; and during the following three years assumed important proportions, but only a small tonnage was shipped in 1922.

The Tariff Act of 1922, which became effective September 22d, last year, placed the following import duties on magnesite: Crude magnesite, $\frac{5}{16}$¢ per lb.; caustic-calcined magnesite $\frac{5}{8}$¢ per lb.; dead-burned and grain magnesite, not suitable for manufacture into oxychloride cements, 23/40¢ per lb.; magnesite brick, $\frac{3}{4}$¢ per lb. and 10% ad valorem. The

figures of imports for 1922, as published by the U. S. Bureau of Foreign and Domestic Commerce, show a total of 119,690 long tons of calcined ore valued at $2,253,227, as compared with the figures shown in the preceding paragraph.

Output and Value.

In considering mineral production, the value of the crude material is used so far as practicable. Magnesite presents a peculiar example of a material which previous to 1916 was seldom handled on the market in the crude state. It is mainly calcined and ground before being considered marketable. From 2 to 2½ tons of crude material are mined to make one ton of the calcined. In the earlier reports an arbitrary value for the crude material at the mine was calculated from the above on the basis of the calcined value, there having been very little product shipped crude. On the contrary, however, considerable tonnages since 1916 have been shipped in the crude state, contracted for at prices ranging from $7 to $17 per ton, f.o.b. rail points. The average was $10.50 per ton, for 1922. This is the basis of the valuation used herein.

The production of crude magnesite in California during the year 1922 totaled 55,637 tons, valued at $594,665 f.o.b. rail-shipping point. This is an increase over the 47,837 tons and $511,102 in 1921.

The strong hope for the future for California magnesite appears to be in the development of the plastic business, particularly in the territory west of the Rocky Mountains and possibly as far east as the Mississippi River; and in the manufacture of refractory brick to be utilized mainly by the copper and lead smelters in the same district. It is possible that California magnesite may be sent via the Panama Canal to the Atlantic seaboard; but, on account of our higher production and transportation costs, it is difficult to compete with the Grecian article at Atlantic ports.

Several plants are reported making refractory brick here from California magnesite. The ore from the White Rock Mine in Napa County, and that from the old Kolling (Refractory Magnesite Company) Mine, Sonoma County, is a natural ferro-magnesite and has found a ready market for refractory purposes. Both of these properties are at present (September, 1923) shut down, but similar material is being shipped from the Blanco Mine, Napa County, and from the Sampson Mine, San Benito County.

In 1918, for the first time since Tulare County became an important producer of this mineral, it was surpassed in tonnage output for the year, but regained the lead in 1919, followed by Santa Clara and Napa counties, respectively. The same ranking was retained in 1920; but Santa Clara took the lead in 1921. The largest individual producer in 1920–1922 has been the Western Magnesite Development Company, in Santa Clara County, operated under lease by C. S. Maltby. A total of 24,091 tons was reported as shipped calcined by Californian mines in 1922, representing approximately 52,205 tons of crude ore.

Owing to increased building operations, and the duty on foreign importations, the outlook for magnesite is improving. Research work is being conducted by the larger operators to insure uniformity of product, and to work out formulæ and mixtures for its application in the plastic trade. Present quotations (September) are reported at $14 per ton crude, f.o.b. California points, and $35–$40 per ton calcined.

Production of crude magnesite for 1922, by counties, is given in the following table, with total crude value:

County	Tons	Value
Santa Clara	28,650	$301,875
Stanislaus	2,400	35,475
Tulare	17,223	181,842
Fresno, Napa, San Benito, Tuolumne*	7,364	75,473
Totals	55,637	$594,665

*Combined to conceal output of a single operator in each.

Total Magnesite Production of California.

The first commercial production of magnesite in California was made in the latter part of 1886 from the Cedar Mountain district,[1] southeast of Livermore, Alameda County. Shipments amounting to 'several tons' or 'several carloads' were sent by rail to New York; but there is apparently no exact record of the amount for that first year. The statistical records of the State Mining Bureau began with the year 1887, and the table herewith shows the figures for amount and value, annually, from that time. Shipments of magnesite from Napa County began in 1891 from the Snowflake Mine; from the Red Mountain deposits in Santa Clara County, in 1899; and from Tulare County in 1900.

Production of Magnesite in California, Since 1887.

Year	Tons	Value	Year	Tons	Value
1887	600	$9,000	1906	4,032	$40,320
1888	600	9,000	1907	6,405	57,720
1889	600	9,000	1908	10,582	80,822
1890	600	9,000	1909	7,942	62,588
1891	1,500	15,000	1910	16,570	113,887
1892	1,500	15,000	1911	8,858	67,430
1893	1,093	10,930	1912	10,512	105,120
1894	1,440	10,240	1913	9,632	77,056
1895	2,200	17,000	1914	11,438	114,380
1896	1,500	11,000	1915	30,721	283,461
1897	1,143	13,671	1916	154,052	1,311,893
1898	1,263	19,075	1917	209,648	1,976,227
1899	1,280	18,480	1918	83,974	803,492
1900	2,252	19,333	1919	44,696	452,094
1901	4,726	43,057	1920	83,695	1,033,491
1902	2,830	20,655	1921	47,837	511,102
1903	1,361	20,515	1922	55,637	594,665
1904	2,850	9,298			
1905	3,933	16,221	Totals	829,502	$7,981,223

MARBLE.

Bibliography: State Mineralogist Reports XII–XV (inc.), XVII, XVIII. Bulletin 38. U. S. Bur. of Mines, Bull. 106.

Marble is widely distributed in California, and in a considerable variety of colors and grain. During 1922, production from one operator each in Imperial, Inyo, and San Diego counties, and two in Tuolumne, amounted to 38,321 cubic feet, valued at $127,792, being an

[1]See U. S. Geol. Surv.; Mineral Resources of U. S., 1886, pp. 6 and 696.

increase both in quantity and value over the 1921 figures. This is again approaching what might be considered the normal output of earlier years, though still far below our possibilities.

California has many beautiful and serviceable varieties of marble, suitable for almost any conceivable purpose of construction or decoration. In the decorative class are deposits of onyx marble of beautiful coloring and effects. There is also serpentine marble suitable for electrical swithboard use.

Marble Production of California, by Years.

Data on annual production since 1887, as compiled by the State Mining Bureau, follows. Previous to 1894 no records of amount were preserved.

Marble colums (monolithic), in Public Library, Stockton, Cal., built in 1893. Marble from Carrara Quarry, Amador County, Cal. Now being reopened. Photo by A. G. Dondero, owner.

Year	Cubic feet	Value	Year	Cubic feet	Value
1887		$5,000	1906	31,400	$75,800
1888		5,000	1907	37,512	118,066
1889		87,030	1908	18.653	47.665
1890		80,000	1909	79,600	238,400
1891		100.000	1910	18,960	50,200
1892		115,000	1911	20,201	54.103
1893		40,000	1912	27,820	74,120
1894	38,441	98,326	1913	41,654	113,282
1895	14,864	56,566	1914	25.436	48.832
1896	7,889	32,415	1915	22,186	41,518
1897	4,102	7,280	1916	25,954	50,280
1898	8,050	23,594	1917	24,755	62,950
1899	9,682	10,550	1918	[a]17,428	49,898
1900	4,103	5,891	1919	25,020	74,482
1901	2,945	4,630	1920	[b]29,531	92,899
1902	19,305	37,616	1921	30,232	98,395
1903	84,624	97,354	1922	38,321	127,792
1904	55,401	94,208			
1905	73,303	129,450	Total value		$2,448,592

[a]Includes onyx and serpentine.
[b]Includes onyx.

ONYX and TRAVERTINE.

Bibliography: State Mineralogist Reports XII–XV (inc.), XVII, XVIII. Bulletin 38.

Onyx and travertine are known to exist in a number of places in California, but there has been only a small and irregular production since the year 1896. As there was but a single operator, the Tolenas Springs quarry, Solano County, in 1918 and 1920, the figures for those years were combined with those of the marble output. In 1922 there were two operators in Solano County and one in Mono, and a total of 10,950 cubic feet, valued at $3,320, was shipped. In the latter county, the travertine deposits near Bridgeport are being reopened, after an idleness of some years, by the Dineen Marble Company of Oakland. Operations are also under way at a new quarry being opened up at Kernville in Kern County. The Solano County material is, in part, being utilized for terrazzo.

Onyx Production of California, by Years.

Production by years was as follows:

Year	Value	Year	Value
1887	$900	1895	$12,000
1888	900	1896	24,000
1889	900	1918	*
1890	1,500	1919	---------
1891	2,400	1920	*
1892	1,800	1921	1,294
1893	27,000	1922	3,320
1894	20,000		
		Total	$96,014

*See under Marble.

SANDSTONE.

Bibliography: State Mineralogist Reports XII–XV, XVII, XVIII. Bulletin 38. U. S. Bur. of M., Bull. 124.

An unlimited amount of high-grade sandstone is available in California, but the wide use of concrete in buildings of every character, as well as the popularity of a lighter-colored building stone, has curtailed production in this branch of the mineral industry during recent years almost to the vanishing point. In 1922 two counties—Santa Barbara and Ventura—turned out 900 cubic feet, valued at $1,100; compared with 10,150 cubic feet and $2,112 in 1921. The main feature of the loss since 1914 is the closing of the well known Colusa quarries, on account of the competition of lighter colored materials.

Sandstone Production of California, by years.

Amount and value, so far as contained in the records of this Bureau, are presented herewith, with total value from 1887 to date:

Year	Cubic feet	Value	Year	Cubic feet	Value
1887		$175,000	1906	182,076	$164,068
1888		150,000	1907	159,573	148,148
1889		175,598	1908	93,301	55,151
1890		100,000	1909	79,240	37,032
1891		100,000	1910	165,971	80,443
1892		50,000	1911	255,313	127,314
1893		26,314	1912	66,487	22,574
1894		113,592	1913	62,227	27,870
1895		35,373	1914	111,691	45,322
1896		28,379	1915	63,350	8,438
1897		24,086	1916	17,270	10,271
1898		46,384	1917	31,090	7,074
1899	56,264	103,384	1918	900	400
1900	378,468	254,140	1919	5,400	3,720
1901	266,741	192,132	1920	10,500	2,300
1902	212,123	142,506	1921	10,150	2,112
1903	353,002	585,309	1922	900	1,100
1904	363,487	567,181			
1905	302,813	483,268	Total value		$4,095,983

SERPENTINE.

Bibliography: State Mineralogist Report XV. Bulletin 38.

Serpentine has not been produced in California to a very large extent at any time. A single deposit, that on Santa Catalina Island, has yielded the principal output to date. Some material was shipped from there in 1917 and 1918, being the only output recorded since 1907. It was used for decorative building purposes and for electrical switchboards. As there was but a single operator, the figures were combined with those of marble output for those years.

Serpentine Production of California, by years.

The following table shows the amount and value of serpentine from 1895 as recorded by this Bureau:

Year	Cubic feet	Value	Year	Cubic feet	Value
1895	4,000	$4,000	1904	200	$2,310
1896	1,500	6,000	1905		
1897	2,500	2,500	1906	847	1,694
1898	750	3,000	1907	1,000	3,000
1899	500	2,000	1917	[1]	[1]
1900	350	2,000	1918	[2]	[2]
1901	89	890	1919		
1902	512	5,065			
1903	99	800	Totals	12,347	$33,259

[1]Under 'Unapportioned.'
[2]See under Marble.

SLATE.

Bibliography: State Mineralogist Reports XV, XVIII. Bulletin 38. U. S. Geol. Surv., Bull. 586. U. S. Bur. of Mines, Bull. 218.

Slate was first produced in California in 1889. Up to and including 1910 such production was continuous, but since then it has been irregular. Large deposits of excellent quality are known in the state, especially in El Dorado, Calaveras and Mariposa counties, but the demand has been light owing principally to competition of cheaper roofing materials.

'Slate' is a term applied to a fine-grained rock that has a more or less perfect cleavage, permitting it to be readily split into thin, smooth sheets. Varieties differ widely in color and have a considerable range in chemical and mineralogical composition. Excepting certain rare slates of igneous origin (of which the green slate of the Eureka quarry, El Dorado County, California, is an example) formed from volcanic ash or igneous dikes, slates have originated from sedimentary deposits consisting largely of clay. By consolidation, and the pressure of superimposed materials, clays become bedded deposits of shale. By further consolidation under intense pressure and high temperature incident to mountain-building forces, shales are metamorphosed to slates. The principal mineral constituents are mica, quartz, and chlorite, with smaller varying amounts of hematite, rutile, kaolin, graphite, feldspar, tourmaline, calcite, and others.

The color of slate is of economic importance. The common colors are gray, bluish gray, and black, though reds and various shades of green are occasionally found.

The permanency of slate for roofing is well known. It is stated that there are slate roofs in Pennsylvania and Maryland over 100 years old.

[1]"In England and Wales, and in France, many buildings constructed in the 15th and 16th centuries were roofed with slate, and the roofs are still in excellent condition. There is a record of a chapel in Bedford-on-Avon in Wiltshire, England, roofed with slate in the 8th century, and after 1200 years of climatic exposure is moss-covered but in good condition."

Contrary to the general impression, however, the major portion of the slate produced in the United States is used on the inside rather than the outside of buildings. Its interior uses include stationary washtubs, electrical switchboards, and blackboards.

A square of roofing slate is a sufficient number of pieces of any size to cover 100 square feet of roof, with allowance generally for a three-inch lap. The sizes of the pieces of slate making up a square range from 7 x 9 inches to 16 x 24 inches, and the number of pieces in a square ranges from 85 to 686. The Ferry Building, San Francisco, is roofed with Eureka slate from El Dorado County.

In California, at present, commercial output is being renewed. The Losh quarry near Placerville, El Dorado County, was opened up in 1921, and some material marketed in 1922; but as it was the only producer, the figures are concealed under the 'unapportioned' item. The Pacific quarry at Hornitos, Mariposa County, is also being reopened, and expects to make shipments during the current year.

[1]Bowles, O., Slate as a permanent roofing material: U. S. Bur. of M., Reports of Investigations, Serial No. 2267, July, 1921, p. 4.

Total Production of Slate in California.

A complete record of amount and value of slate produced in California follows:

Year	Squares	Value	Year	Squares	Value
1889	4,500	$18,089	1904	6,000	$50,000
1890	4,000	24,000	1905	4,000	40,000
1891	4,000	24,000	1906	10,000	100,000
1892	3,500	21,000	1907	7,000	60,000
1893	3,000	21,000	1908	6,000	60,000
1894	1,800	11,700	1909	6,961	45,660
1895	1,350	9,450	1910	1,000	8,000
1896	500	2,500	1911	----------	----------
1897	400	2,800	1915	1,000	5,000
1898	400	2 800	1916	----------	----------
1899	810	5,900	1920	8	80
1900	3,500	26,250	1921	----------	----------
1901	5,100	28,250	1922	*	*
1902	4 000	30,000			
1903	10,000	70,000	Totals	88,829	$676,479

*Concealed under 'Unapportioned.'

MISCELLANEOUS STONE.

Bibliography: State Mineralogist Reports XII–XVIII. Bulletin 38.

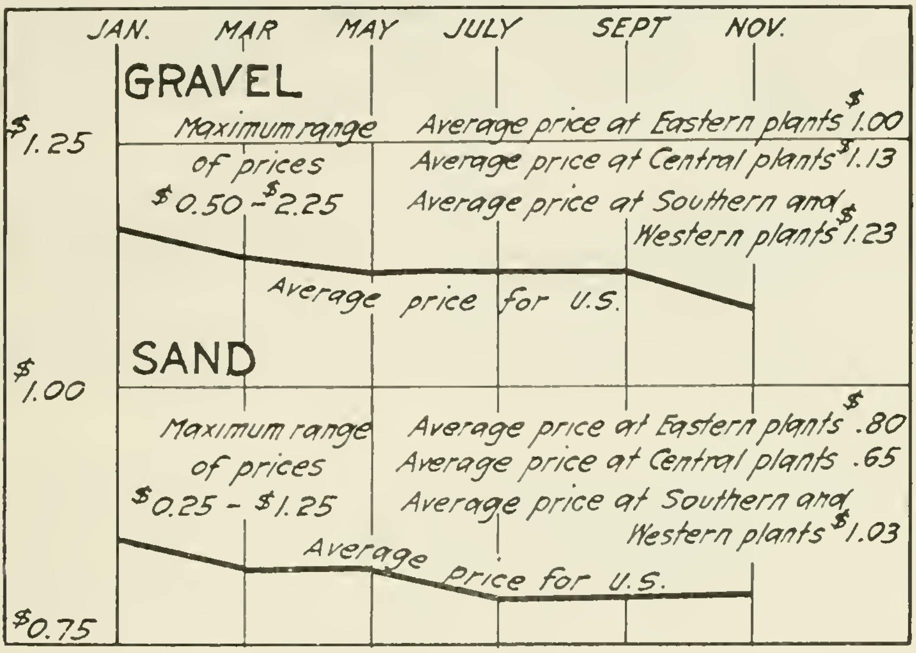
'Miscellaneous stone' is the name used throughout this report as the title for that branch of the mineral industry covering crushed rock of all kinds, paving blocks, sand and gravel, and pebbles for grinding mills. The foregoing are very closely related from the standpoint of the producer; therefore it has been found to be most satisfactory to group these items as has been done in recent reports of this Bureau. So far as it has been possible to do so, crushed rock production has been subdivided into the various uses to which the product was put. It will be noted, however, a very large percentage of the output has been tabulated under the heading 'Unclassified.' This is necessary because of the fact that many of the producers have no way of telling to what specific use their rock was put after they have quarried and sold the same to distributors and contractors.

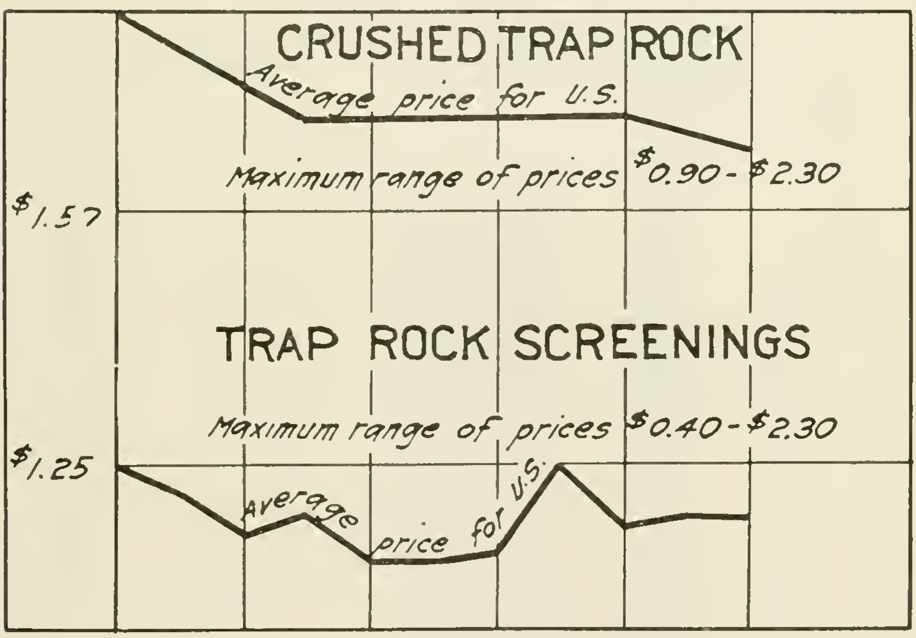
In addition to amounts produced by commercial firms, both corporations and individuals, there is hardly a county in the state but uses more or less gravel and broken rock on its roads. Of much of this, particularly in the country districts, there is no definite record kept. Estimates have been made for some of this output, based on the mileage of roads repaired.

For the year 1922 miscellaneous stone shows an increase both in total tonnage and value over the preceding year, being $10,377,783 as compared with $7,834,640 in 1921. Crushed rock showed a slight decrease in average values per ton; but sand and gravel increased in average unit values reported. In addition to building work in the cities, construction on several hydroelectric power installations have been important factors contributing to the increase. Of these, mention should be made of the Hetch Hetchy dam of San Francisco on the Tuolumne River, and the Dom Pedro dam of the combined Modesto-Turlock irrigation districts on the Tuolumne River. Highway construction continues to utilize large tonnages of rock, gravel, and cement throughout the state.

In 1922, as has been the case for some years past, Los Angeles County led all others by a wide margin, with an output valued at \$3,390,477; followed by Alameda, second, with \$760,422; Fresno, third, \$600,348; Contra Costa, fourth, \$559,915; Sacramento, fifth, \$412,667; and Riverside, sixth, \$400,560.

The following is quoted, and the charts reproduced, from one of the trade journals[1] relative to the average prices obtaining for crushed rock, sand and gravel, throughout the United States during 1922. The results, on the whole, indicate larger quantities used at somewhat lower unit values:





"Sand and Gravel.

"The general level of prices for both sand and gravel is lower than it has been in either of the past two years, but these products have been subject to much less variation in price than during 1921. In that year gravel dropped, as shown in the general price curves of rock products a year ago, from \$1.28 in January to \$1.12 in November,

[1]Prices of rock products in 1922; Rock Products, Vol. XXV, pp. 102–104, Dec. 30, 1922.

while during 1922 the range was from $1.16 in January to $1.09 in November. A large number of plants reported a constant price throughout the year on both sand and gravel, and this fact accounts for the comparatively flat appearance of the two curves.

"With sand the average price dropped in 1921 from 98 cents to 84 cents, while in 1922 the decline is from 83 cents to 79 cents. It is worth noting that in both years the tendency has been downward, and that the general level for 1922 is lower than for 1921. During 1920 both curves had an upward turn.

"This downward tendency with these two products during two years is due partly, without question, to an easing up of the labor situation during that period. Early 1921 prices still showed the effects of 1920's high labor costs, and as the lower wages became generally effective prices reacted to a lower level. An upward turn of wages during the last half of 1922 has not made itself felt in increased prices for aggregate as it has in the case of cement and lime.

"Probably another reason why lower prices are possible is the increasing use of labor-saving machinery in the industry with resulting lower costs of production. New plants are not only being designed and built to reduce the number of men needed, and old ones rebuilt with the same purpose, but they are so planned as to reduce the break-downs and the number of hours the plant is not operating because of break-downs.

"With only a few exceptions, prices at Eastern plants remained particularly steady throughout the year. In the Central and Southern sections there was a tendency to vary, up at one point and down at another, while at the Western plants prices reported showed as a whole a decline toward the end of the season.

* * * * * * *

"Trap Rock.

"Crushed trap rock, largely because of its higher cost of quarrying and crushing, is the most expensive of the three more common of the coarse aggregates. Like gravel and crushed limestone, trap suffered a decline in general price level from 1921, and also a decline through the year 1922. The average price of crushed trap rock in January, 1922, was $1.70; during the summer it remained constant at $1.59; and in November it had declined to $1.56. During 1921 this same product dropped in price from $1.79 in January to $1.60 in November.

"Trap rock screenings dropped from $1.25 in January to a low point of $1.15 in May and June, went back to $1.25 in August and finished the year at $1.20 in October and November."

Paving Blocks.

The paving block industry has decreased materially of recent years, almost to the vanishing point, because of the increased construction of smoother pavements demanded by motor-vehicle traffic. The blocks made in Solano County were of basalt; those from Sonoma are of basalt, andesite, and some trachyte, while those from Placer, Riverside, San Bernardino, and San Diego are of granite.

Production in 1922 amounted to only 72 M., valued at $3,924.

The amount and value of paving block production annually since 1887 has been as follows:

Year	Amount M	Value	Year	Amount M	Value
1887	*10,000	$350,000	1906	4,203	$173,432
1888	10,500	367,500	1907	4,604	199,347
1889	7,303	297,236	1908	7,660	334,780
1890	7,000	245,000	1909	4,503	199,803
1891	5,000	150,000	1910	4,434	198,916
1892	*3,000	96,000	1911	4,141	210,819
1893	2,770	96,950	1912	11,018	578,355
1894	2,517	66,981	1913	6,364	363,505
1895	2,332	73,338	1914	6,053	270,598
1896	4,161	77,584	1915	3,285	171,092
1897	1,711	35,235	1916	1,322	54,362
1898	1,144	21,725	1917	938	38,567
1899	305	7,861	1918	372	17,000
1900	1,192	23,775	1919	27	1,350
1901	1,920	41,075	1920	63	3,155
1902	3,502	112,437	1921	4	286
1903	4,854	134,642	1922	72	3,921
1904	3,977	161,752			
1905	3,408	134,347	Totals	135,619	$5,312,723

*Figures for 1887–1892 (inc.) are for Sonoma County only, as none are available for other counties during that period; though Solano County quarries were then also quite active.

Grinding Mill Pebbles.

Production of pebbles for tube and grinding mills began commercially in California in 1915. Owing to the decreased imports and higher prices of Belgium and other European flint pebbles, due to the war, there was a serious inquiry for domestic sources of supply. One of the shipments made in that year was of pebbles selected from gold-dredger tailings in Sacramento County, for use in a gold mill in Amador County employing Hardinge mills.

The important development in this item, however, took place in San Diego County. At several points along the ocean shore from Encinitas south to near San Diego, there are beaches of washed pebbles varying from 1 inch to 6 inches in diameter, which come from conglomerate beds made up of well-rounded water-worn pebbles of various granitic and porphyritic rocks with some felsite and flint. The wave action has broken down portions of the cliffs for considerable distances and formed beaches of the pebbles which are well washed and cleaned of the softer materials. The rocks sorted out for shipment are mainly basalt and diabase, with an occasional felsite and flint pebble. There is a tough black basalt which is stated to give satisfactory results. In Fresno County pebbles have been selected from the gravel beds of the San Joaquin River near Friant. Shipments have been made to metallurgical plants in California, Nevada, Montana and Utah.

Imports in 1919, amounted to 17,677 long tons, valued at $250,096; 23,782 tons and $338,630 in 1920; 9004 tons and $116,157 in 1921; 14,321 tons and $145,805 in 1922. California output for 1922 was 1571 tons, valued at $7,628, an increase over the 1921 figures.

The amount and value of grinding mill pebbles, annually, follows:

Year	Tons	Value
1915	340	$2,810
1916	20,232	107,567
1917	21,450	90,538
1918	8,628	61,268
1919	2,607	19,272
1920	2,104	17,988
1921	247	1,418
1922	1,571	7,628
Totals	57,179	$238,489

Sand and Gravel.

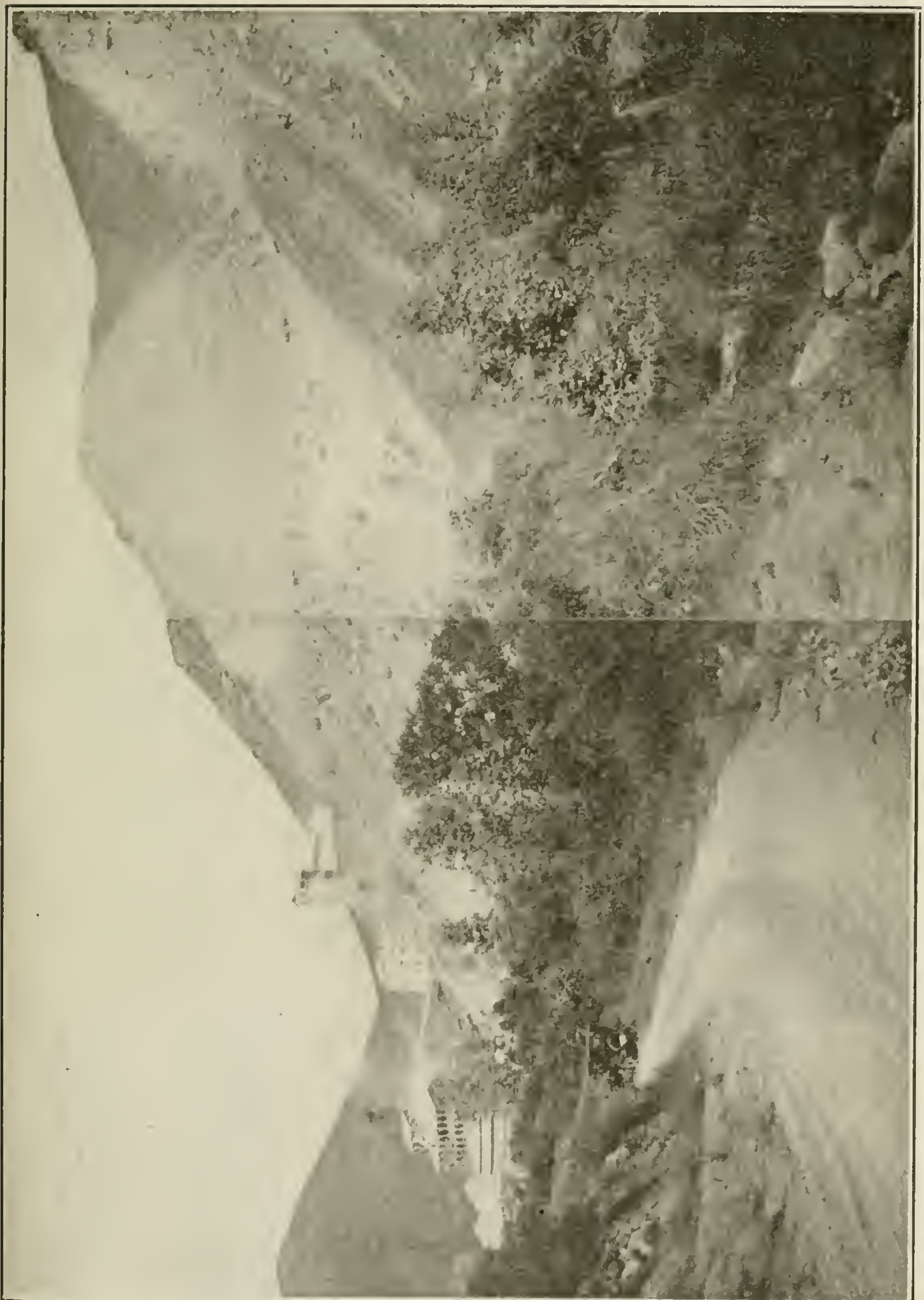
The distribution of the 1922 output of sand and gravel, by counties, is given in the following table:

County	Tons	Value	County	Tons	Value
Alameda	[a]699,863	$495,580	Sacramento	[a]157,233	$96,425
Alpine	5,632	2,800	San Diego	[a]268,478	295,448
Amador	12,747	7,300	San Joaquin	212,690	87,967
Butte	167,653	99,350	San Luis Obispo	28,000	21,000
Calaveras	14,110	6,929	San Mateo	13,881	10,411
Contra Costa	62,136	24,656	Santa Barbara	65,500	51,500
El Dorado	2,500	2,000	Santa Clara	193,915	154,125
Fresno	552,041	291,094	Shasta	54,180	31,344
Glenn	174,241	91,250	Siskiyou	28,005	12,112
Humboldt	48,988	102,308	Solano	27,472	11,040
Imperial	256,942	64,569	Sonoma	128,208	104,039
Kern	35,970	23,585	Stanislaus	337,462	248,462
Lake	23,337	16,669	Tuolumne	72,333	78,100
Lassen	11,823	5,850	Ventura	24,294	27,588
Los Angeles	2,629,631	2,140,828	Yuba	147,447	75,969
Mendocino	14,000	14,000	Colusa, Del Norte, Inyo,		
Merced	125,000	79,500	Madera, Mariposa,		
Monterey	[b]120,083	84,180	Modoc, San Benito,		
Napa	171,383	118,664	Santa Cruz, Sierra,		
Nevada	9,667	6,026	Tehama, Trinity,		
Orange	251,135	225,764	Yolo*	138,206	148,981
Placer	8,333	6,800			
Riverside	[a]17,788	5,650	Totals	7,312,307	$5,369,854

*Combined to conceal output of a single operator in each.
[a]Includes molding sand.
[b]Includes molding, core, building, cutting, grinding, blast and filter sand, mainly from ocean beaches.

Crushed Rock.

To list the kinds and varieties of rocks utilized commercially under this heading would be to run almost the entire gamut of the classification scale. Much depends on the kind available in a given district. Those which give the most satisfactory service are the basalts and other hard, dense, igneous rocks which break with sharp, clean edges. In many localities, river-wash boulders form an important source of such material. In such cases, combined crushing and washing plants obtain varying amounts of sand and gravel along with the crushed sizes. In Sacramento and Butte counties the tailings piles from the gold dredgers are the basis for like operations.



Temescal Quarry and crushing plant of Blue Diamond Material Company, near Corona, Riverside County.
(For detailed description of this plant, see Eng. & Min. Jour.-Press, Nov. 24, 1923, pp. 887-890.)

CRUSHED ROCK PRODUCTION, BY COUNTIES, FOR 1922.

County	Macadam and ballast		Rubble and riprap		Concrete		Unclassified		Totals	
	Tons	Value	Tons	Value	Tons	Value	Tons	Value	Tons	Value
Alameda	28,506	$24,404	3,000	$800	152,804	$210,303	[a][b]22,259	$29,335	206,569	$264,842
Calaveras	2,901	2,176					[c][d]1,864	26,485	4,765	28,661
Contra Costa	*		*		*		487,672	444,243	487,672	444,243
El Dorado	2,000	2,250							2,000	2,250
Humboldt	5,000	15,000							5,000	15,000
Kern	3,000	12,000							3,000	12,000
Los Angeles	1,127,564	942,152	85,570	68,830	185,012	186,912	37,616	[e]51,755	1,435,762	1,249,649
Madera			4,105	2,948					4,105	2,948
Mendocino	3,151	4,726							3,151	4,726
Monterey	2,000	2,000							2,000	2,000
Napa	23,200	34,599			27,666	45,138	[f]867	1,750	51,733	81,487
Nevada	45,900	21,500					*		45,900	21,500
Placer	15,020	15,680	1,500	1,950					16,520	17,630
Riverside			*		*		[e]1,700	8,600	1,700	8,600
Sacramento	1,762	1,042	*				*		1,762	1,042
San Diego	*		565	762	*		100	1,972	665	2,734
San Luis Obispo					54,000	86,000			54,000	86,000
San Mateo	23,023	29,607			*		*		23,023	29,607
Santa Clara							87,966	81,000	87,966	81,000
Santa Cruz	*				2,996	4,098			2,996	4,098
Shasta	31,333	21,431			22,700	12,750			54,033	34,181
Siskiyou	[g]12,428	9,614							12,428	9,614
Sonoma	58,085	58,017	*		*		*		58,085	58,017
Tulare			201	151					201	151
Tuolumne	20,500	18,360			133,000	150,000			153,500	168,360
Contra Costa, Del Norte, Fresno, Inyo, Lassan, Marin, Mariposa, Merced, Modoc, Plumas, San Benito, San Bernardino, San Diego, San Francisco, Santa Barbara, Santa Cruz, Sierra, Stanislaus, Tehama, Trinity, Ventura*	596,984	531,568								
Contra Costa, Imperial, Lassen, Marin, Riverside, Sacramento, San Bernardino, Sonoma*			422,886	251,770						
Contra Costa, Imperial, Lassen, Orange, Riverside, San Benito, San Diego, San Francisco, San Joaquin, San Mateo, Sonoma, Stanislaus*					737,156	679,206				

Butte, Fresno, Nevada, Sacramento, San Bernardino, San Francisco, San Mateo, Santa Barbara, Solano, Sonoma, Ventura*							1,261,775	903,493	3,018,801	2,366,037
Totals	2,002,357	$1,746,126	517,827	$327,211	1,315,334	$1,374,407	1,901,819	$1,548,633	5,737,337	$1,996,377

*Combined to conceal output of a single operator in each. [a]Includes red shale for roofing. [b]Includes toe line cobbles for railroad ballast work. [c]Includes greenstone granules for roofing. [d]Includes yellow 'caen stone' used ground for coloring plaster. [e]Includes roofing granules. [f]Includes basalt screenings used in making concrete drain-pipe. [g]Includes volcanic 'cinders' (obsidian and ash), used for railroad ballast.

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Miscellaneous Stone Production of California, by Years.

The amount and value, annually, of crushed rock (including macadam, ballast, rubble, riprap, and that for concrete), and sand and gravel, since 1893, follow:

Crushed Rock, Sand and Gravel, by Years.

Year	Tons	Value	Year	Tons	Value
1893	371,100	$456,075	1909	5,531,561	$2,708,326
1894	661,900	664,838	1910	5,827,828	2,777,690
1895	1,254,688	1,095,939	1911	6,487,223	3,610,357
1896	960,619	839,884	1912	8,044,937	4,532,598
1897	821,123	600,112	1913	9,817,616	4,823,056
1898	1,177,365	814,477	1914	9,288,397	3,960,973
1899	964,898	786,892	1915	10,879,497	4,609,278
1900	789,287	561,642	1916	9,951,089	4,009,590
1901	530,396	641,037	1917	8,069,271	3,505,662
1902	2,056,015	1,249,529	1918	6,641,144	3,325,889
1903	2,215,625	1,673,591	1919	6,919,188	3,678,322
1904	2,296,898	1,641,877	1920	9,792,122	6,782,414
1905	2,624,257	1,716,770	1921	10,914,145	7,834,640
1906	1,555,372	1,418,406	1922	13,049,644	10,266,231
1907	2,288,888	1,915,015			
1908	3,998,945	3,241,774	Totals	145,781,038	$85,842,884

A comparison of the above table of annual productions of these materials with the similar table for cement (see *ante*), reveals the fact that the important growth of the crushed rock and gravel business has been coincident with the rapid development of the cement industry from the year 1902.

CHAPTER FIVE.

INDUSTRIAL MATERIALS.

Bibliography: Reports XIV, XV. Bulletin 38. Min. & Sci. Press, Vol. 114, March 10, 1917. See also under each substance.

The following mineral substances have been arbitrarily arranged under the general heading of Industrial Materials, as distinguished from those which have a clearly defined classification, such as metals, salines, structural materials, etc.

These materials, many of which are mineral earths, are, with four or five exceptions, as yet produced on a comparatively small scale. The possibilities of development along several of these lines are large and with increasing transportation and other facilities, together with steadily growing demands, the future for this branch of the mineral industry in California is promising. There is scarcely a county in the state but might contribute to the output.

Up to within the last few years, at least, production has been in the majority of instances dependent upon more or less of a strictly local market, and the annual tables show the results of such a condition, not only in the widely varying amounts of a certain material produced from year to year, but in widely varying prices of the same material. Furthermore, the quality of this general class of material will be found to fluctuate, even in the same deposit. The war in Europe affected some of these items, but not to the striking degree that it did the metal markets.

The more important of these minerals thus far exploited, so far as shown by value of the output, are limestone, mineral water, pyrites, pottery clays, diatomaceous earth, gypsum, talc, and dolomite. Two new substances were added to the commercial list in 1922, namely, shale oil and sillimanite.

This group as a whole showed a slight increase in the total value from $2,675,438 for 1921 to $2,834,748 in 1922. The principal losses were by diatomaceous earth, limestone, silica and asbestos. Important increases were shown by clay, gypsum, mineral water, and pyrites.

The following table gives the comparative figures for the amounts and values of industrial materials produced in California during the years 1921 and 1922:

Substance	1921 Amount	1921 Value	1922 Amount	1922 Value	Increase+ Decrease— Value
Asbestos	410 tons	$19,275	50 tons	$1,800	$17,475—
Barytes	901 tons	4,809	3,370 tons	18,925	14,116+
Clay (pottery)	225,120 tons	362,172	277,232 tons	473,184	111,012+
Dolomite	31,195 tons	99,155	52,409 tons	114,911	15,756+
Feldspar	4,349 tons	28,343	4,587 tons	37,109	8,766+
Fuller's earth	1,185 tons	8,295	6,606 tons	48,756	40,461+
Gems		10,954		1,312	9,642—
Graphite	*	*	*	*	* +
Gypsum	37,412 tons	78,875	47,084 tons	188,336	109,461+
Infusorial and diatomaceous earths	*	*	*	*	* —
Limestone	75,921 tons	305,912	84,382 tons	282,181	23,731—
Lithia	*	*	*	*	* —
Mineral paint	446 tons	4,748	1,620 tons	13,277	8,529+
Mineral water	3,446,278 gals.	367,476	4,276,346 gals.	486,424	118,948+
Pumice and volcanic ash	406 tons	6,310	613 tons	4,248	2,062—
Pyrites	110,025 tons	473,735	151,381 tons	570,425	96,690+
Shale oil			*	*	* +
Silica (sand and quartz)	10,569 tons	49,179	9,874 tons	31,016	18,163—
Sillimanite			*	*	* +
Soapstone and talc	8,752 tons	130,078	13,378 tons	197,186	67,108+
Unapportioned[1]		726,122		365,658	360,464—
Total values		$2,675,438		$2,834,748	
Net increase					$159,310+

*Combined under 'Unapportioned.'
[1]In 1921 includes graphite, diatomaceous earth and lithia; in 1922 includes graphite, diatomaceous earth, lithia, shale oil, and sillimanite.

ASBESTOS.

Bibliography: State Mineralogist Reports XII, XIII, XIV, XV, XVI, XVII, XVIII. Bulletins 38, 91. Canadian Dept. of M., Mines Branch Bulletin 69. Min. & Sci. Press, April 10, 1920, pp. 531–533. Eng. & Min. Jour.-Press, Vol. 113, pp. 617–625; 670–677.

In 1922 a total of 50 tons of asbestos fibre, valued at $1,800, was shipped from Monterey, San Benito, and Shasta counties, by a single operator in each. This was a considerable decrease from the 410 tons, worth $19,275, produced in 1921; due mainly to there having been no shipments from Nevada County which has been the principal producer for several years past.

The Monterey County product was of spinning-grade fibre. The bulk of the yield was of short-fibre mill grade, and was utilized mainly in magnesite-cement stucco, steam-pipe covering, flooring, composition shingles and roofing paper. The outlook for asbestos becoming an important industry in California is promising. There are extensive serpentine areas in the Coast Ranges, in the Klamath Mountains, and in several sections of the Sierra Nevada, which localities came to the fore in yielding chromite during the war period. As chrysotile asbestos is a fibrous form of serpentine, these areas are all within the range of possible asbestos producers. In addition to the above-mentioned pro-

ducing counties, chrysotile of good-quality fibre, though short, has also been found in Calaveras, Lake, Napa, Shasta, Siskiyou, and Trinity counties. Reports of the U. S. Geological Survey also confirm the promising quality of the California fibre.

Classification and Characteristics.

The word asbestos (derived from the Greek, meaning incombustible) as used here includes several minerals, from a strictly mineralogical standpoint. There are two main divisions, however: Amphibole and chrysotile. The fibrous varieties of several of the amphiboles (silicates chiefly of lime, magnesia and iron), notably tremolite and actinolite, are called asbestos. Their fibres usually lie parallel to the fissures containing them. Amphibole asbestos possesses high refractory properties, but lacks strength of fibre, and is applicable principally for covering steam pipes and boilers. Chrysotile, a hydrous silicate of magnesia, is a fibrous form of serpentine, and often of silky fineness. Its fibres are formed at right angles to the direction of the fissures containing them. Chrysotile fibres, though short, have considerable strength and elasticity, and may be spun into threads and woven into cloth. To bring the highest market price asbestos must needs have a combination of properties, *i. e.*, length and fineness of fibre, tensile strength and flexibility—all combined with infusibility; and determination of the same can only be made by practical tests or in the laboratory. In the two years prior to 1914, chrysotile asbestos was sold at prices ranging from $10 to $250, according to length of fibre and quality. Almost fabulous figures were reached for extra-long spinning fibre in 1918, and proportionate levels for other grades. Prices have since receded from those high levels; but statements issued by some of the important marketing concerns indicate that the unprofitable low prices of 1912–1914 will not again obtain. The extreme high values quoted for extra-long fibre material are misleading to one looking for average values in the industry. In Canada the shorter, 'mill-stock' grades constitute over 95% of the merchantable asbestos, and are quoted at present at approximately $10 to $150 per ton.

The poorer grades which are unsuitable for weaving are used in the manufacture of steam packing, furnace linings, asbestos brick, wall plasters, paints, tiling, asbestos board, shingles, insulating material, magnesite-stucco, etc. The better grades are utilized in the manufacture of tapestries of various kinds, fireproof theater curtains, cloth, rope, etc.

A very important development of the asbestos industry is the rapidly increasing demand for the lower-grade material, on account of the numerous diversified uses to which asbestos products are being put, in almost every branch of manufacture. This fact means that many deposits of asbestos will become commercially important even though of the shortest fibre.

It has been found that not only does an asbestos wall-plaster render the wall so covered impervious to heat, but that in rooms which have given forth an undesirable echo this evil has been absolutely removed. Asbestos pulp mixed with magnesite-cement has been experimented with; and roofing, flooring and other building material of the most satisfactory sort are now being manufactured therefrom.

The bulk of the world's supply of asbestos has, for many years, come from Canada. Shipments from South Africa are also becoming important. In the United States, long-fibre chrysotile is being obtained in Arizona which is the equal, if not superior, in quality to the Canadian.

Value and Production of Asbestos in California.

Total amount and value of asbestos production in California since 1887, as given in the records of this Bureau, are as follows:

Year	Tons	Value	Year	Tons	Value
1887	30	$1,800	1906	70	$3,500
1888	30	1,800	1907	70	3,500
1889	30	1,800	1908	70	6,100
1890	71	4,260	1909	65	6,500
1891	66	3,960	1910	200	20,000
1892	30	1,830	1911	125	500
1893	50	2,500	1912	90	2,700
1894	50	2,250	1913	47	1,175
1895	25	1,000	1914	51	1,530
1896	-----	-----	1915	143	2,860
1897	-----	-----	1916	145	2,380
1898	10	200	1917	136	10,225
1899	30	750	1918	229	9,903
1900	50	1,250	1919 } *	131	6,240
1901	110	4,400	1920 }		
1902	-----	-----	1921	410	19,275
1903	-----	-----	1922	50	1,800
1904	10	162			
1905	112	2,625	Totals	2,736	$128,775

*Annual details concealed under 'Unapportioned.'

BARYTES.

Bibliography: State Mineralogist Reports XII, XIV, XV, XVII. Bulletin 38. Eng. & Min. Jour.-Press, Vol. 114, p. 109, July 15, 1922; Vol. 115, pp. 319–324, Feb. 17, 1923.

The output of crude barytes in California during 1922 was 3370 tons valued at $18,925, as compared with 1921 production of 901 tons, worth $4,809. This included, in part, witherite ($BaCO_3$) from the deposit at El Portal, Mariposa County, which yields both the sulphate and carbonate. Most of the output of barytes in California, at present, is being utilized in the manufacture of lithopone.

The principal uses for barytes, after washing and grinding, are as an inert pigment and filler in paint, paper, linoleum, oilcloth and rubber manufacture, and in the preparation of lithopone and a number of chemicals. The most important of such chemicals, other than lithopone, are: barium binoxide (used in preparation of hydrogen peroxide); barium carbonate (used by pressed brick and by rubber manufacturers to neutralize sulphur content); barium chloride (used in battery plates, and as a mordant by dry-color manufacturers, and in tanning leather); barium nitrate (used in munitions and in making 'red fire' material); barium sulphate precipitated, or 'blanc fixe' (used in rubber manufacture; for painting on interior steel of battleships and other sea-going vessels; also as a detector in taking X-ray pictures of the human body).

More than half of the total tonnage of barytes utilized in the United States is taken in the manufacture of lithopone. This is a chemically-

prepared, white pigment containing about 70% barium sulphate and 30% zinc sulphide, and is one of the principal constituents of 'flat' wall paints now so extensively used in office buildings and hospitals, replacing both paper and calcimine wall finishes. Present quotations for barytes vary from $5 to $9 per ton, crude, f.o.b. rail-shipping point, depending on quality. Most barite has to be washed and acid-treated to remove iron stains or other impurities before being suitable for paint use.

Known occurrences of this mineral in California are located in Inyo, Los Angeles, Mariposa, Monterey, Nevada, San Bernardino, Shasta and Santa Barbara counties. The deposit at El Portal, in Mariposa County, has given the largest commercial production to date, in part witherite (barium carbonate, $BaCO_3$). The 1915 output was the first commercial production of the carbonate in the United States of which we have record. In 1916–1920, some tonnage of barytes came from a deposit opened up on Fremont's Peak, Monterey County, near the line of San Benito County; in 1919–1922, shipments were made from Nevada County. Shasta County is in the list for 1921–1922.

Total Barytes Production of California.

The first recorded production of barytes in California, according to the statistical reports of the State Mining Bureau, was in 1910. The annual figures are as follows:

Year	Tons	Value	Year	Tons	Value
1910	860	$5,640	1918	100	$1,500
1911	309	2,207	1919	1,501	18,065
1912	564	2,812	1920	3,029	20,795
1913	1,600	3,680	1921	901	4,809
1914	2,000	3,000	1922	3,370	18,925
1915	410	620			
1916	1,606	5,516	Totals	20,670	$113,202
1917	4,420	25,633			

CLAY (pottery).

Bibliography: State Mineralogist Reports I, IV, IX, XII–XV, XVII, XVIII. Bulletin 38. Preliminary Report No. 7.

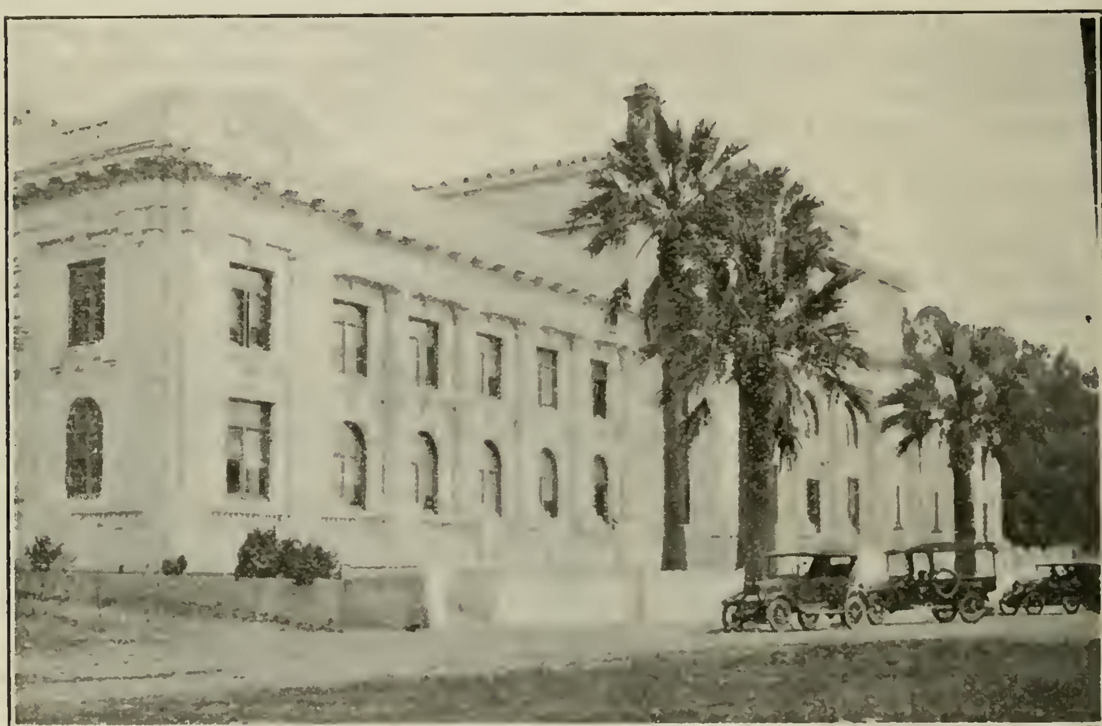
At one time or another in the history of the state, pottery clay has been quarried in thirty-three of its counties. In this report, 'pottery clay' refers to all clays used in the manufacture of red and brown earthenware, china and sanitary ware, flowerpots, floor, faience and ornamental tiling, architectural terra cotta, sewer pipe, drain and roof tile, etc., and the figures for amount and value are relative to the crude material at the pit, without reference to whether the clay was sold in the crude form, or whether it was immediately used in the manufacture of any of the above finished products by the producer. It does not include clay used in making brick and building blocks.

There are many other important uses for clays besides pottery manufacture. Among these may be enumerated, paper, cotton goods, and chemicals. Being neutral, clay does not have an injurious effect upon other constituents used in the manufacture of such articles. In paper making, clay is used as a filler in news and similar grades, and as a

coater or glazer in the more highly finished art papers. A large part of the china clay used in the United States is imported from England. Clays of the montmorillonite and halloysite group ('rock soap') are being utilized successfully in the manufacture of soaps.

During 1922, a total of 39 producers in 14 counties reported an output of 277,232 short tons of pottery clays, having a total value of $473,184 f.o.b. rail-shipping point, for the crude material, as compared with the 1921 production of 225,120 tons worth $362,172.

Because of the fact that a given product often requires a mixture of several different clays, and that these are not all found in the same pit, it is necessary for most clay-working plants to buy some part of their raw materials from other localities. For these reasons, in compiling the clay industry figures, much care is required to avoid duplications. So



County Court House at Ventura, California. Finished in white, architectural terra cotta from Gladding, McBean & Co., Lincoln, Placer County, California, and built in 1894.

far as we have been able to segregate the figures, from the data sent in by the operatives, we have credited the clay output to the counties from which the raw material originated; and have deducted tonnages used in brick manufacture, as bricks are classified separately, herein.

A tabulation of the direct returns from the producers, by counties, for the year 1922, is shown herewith:

POTTERY CLAY IN 1922.

County	Tons	Value	Used in the manufacture of—
Amador	[a]39,572	$68,126	Architectural terra cotta, porcelain, stoneware, fire clay products, sewer pipe, etc.
Contra Costa	7,086	12,910	Architectural terra cotta, porcelain, chimney and sewer pipe, drain and building tile.
Humboldt	303	645	Art pottery, drain tile.
Los Angeles	54,924	66,519	Crushed brick for roofing and roofing tile, red earthenware, stoneware, fire clay and grog.
Placer	79,531	111,166	Architectural terra cotta, drain, roofing, mantel, floor and faience tile, garden pottery, sewer pipe, sanitary ware and various.
Riverside	[b]81,577	181,897	Architectural terra cotta, floor and faience tile, grog, porcelain, stoneware, fire clay, sewer pipe and various.
San Diego	[c]1,393	12,545	Tile, pottery, crushed tile roofing.
Santa Clara	3,836	7,372	Red earthenware, grog and crushed brick for roofing.
Alameda, Calaveras, Inyo, Orange, San Joaquin, and Sonoma	9,010	12,004	Drain tile, flue lining, sewer and chimney pipe, porcelain and fire clay.
Totals	277,232	$473,184	

[a]Includes washed kaolin.
[b]Includes ball clay.
[c]Includes 'Cornwall stone' used in pottery.

Pottery Clay Products.

The values of the various pottery clay products made in California during 1922 totaled $7,562,698, compared with $5,478,848 in 1921, their distribution being shown in the following tabulation:

VALUES OF POTTERY CLAY PRODUCTS, 1922.

Product	Number of producers	Value
Architectural terra cotta	5	$1,862,647
Chimney pipe, terra cotta, and flue linings	5	155,924
Drain tile	8	70,315
Roofing tile	6	772,422
Sewer pipe	9	1,710,840
Stoneware, chemical and sanitary ware	11	2,007,019
Red earthenware	3	121,226
Floor, faience, mantel, glazed and hand-made tile	13	684,036
Miscellaneous art pottery, terra cotta, garden furniture, mortar colors, vitrified conduit, bisque ware, grog and fire clay	13	178,239
Total value		$7,562,698

Important increases were shown by all of the above except drain tile, which decreased slightly. The largest increase in value was by the stoneware, chemical and sanitary ware group.

Pottery Clay Production of California, by Years.

Amount and value of crude pottery clay output in California since 1887 are given in the following table:

Year	Tons	Value	Year	Tons	Value
1887	75,000	$37,500	1906	167,267	$162,283
1888	75,000	37,500	1907	160,385	254,454
1889	75,000	37,500	1908	208,042	325,147
1890	100,000	50,000	1909	299,424	465,647
1891	100,000	50,000	1910	249,028	324,099
1892	100,000	50,000	1911	224,576	252,759
1893	24,856	67,284	1912	199,605	215,683
1894	28,475	35,073	1913	231,179	261,273
1895	37,660	39,685	1914	179,948	167,552
1896	41,907	62,900	1915	157,866	133,724
1897	24,592	30,290	1916	134,636	146,538
1898	28,947	33,747	1917	166,298	154,602
1899	40,600	42,700	1918	112,423	166,788
1900	59,636	60,956	1919	135,708	245,019
1901	55,679	39,144	1920	203,997	440,689
1902	67,933	74,163	1921	225,120	362,172
1903	90,972	99,907	1922	277,232	473,184
1904	84,149	81,952			
1905	133,805	130,146	Totals	4,576,945	$5,612,060

DOLOMITE.

Bibliography: Reports XV, XVII, XVIII. Bulletins 67, 91.

Previous to the 1915 report dolomite was included under limestone. Limestones are frequently more or less magnesian-bearing, and a chemical analysis is often necessary to definitely decide as to whether they are calcite or dolomite; the latter standing intermediate betwen magnesite ($MgCO_3$) and calcite ($CaCO_3$). Since dolomite, as such, has been found to have certain distinctive applications, we have given it a separate classification.

An important part of the tonnage being shipped is utilized as a refractory lining in the bottoms of open-hearth steel furnaces, as a substitute for magnesite. A portion is used for its carbonic acid gas (CO_2), and part for its magnesia. We are also informed that some calcined dolomite has been used by the paper mills. As dolomite contains the proper proportions of lime and magnesia, it can replace an artificial mixture of calcined limestone and magnesite in the sulphite process of manufacture of paper from wood pulp. Dolomite is also sometimes used as a flux in metal smelting.

The dolomite production in Inyo County is utilized for its CO_2 by the chemical plants on Owens Lake, in the manufacture of soda ash and bicarbonate from the waters of the lake. The Tuolumne County material is burned for the preparation of a dolomitic lime.

The production of dolomite for the year 1922 showed an increase both in tonnage and value over the 1921 output, and amounted to

52,409 tons, valued at $114,911, from a total of 8 quarries in 4 counties, distributed as follows:

County	Tons	Value
Inyo	43,778	$72,284
San Benito	6,650	30,100
Monterey, Tuolumne*	1,981	12,527
Totals	52,409	$114,911

*Combined to conceal output of a single operator in each.

Dolomite Production of California, by Years.

Amount and value of the output of dolomite, annually, have been as follows:

Year	Tons	Value
1915	4,192	$14,504
1916	13,313	46,566
1917	27,911	66,416
1918	24,560	79,441
1919	24,502	67,953
1920	42,388	132,791
1921	31,195	99,155
1922	52,409	114,911
Totals	220,470	$621,737

FELDSPAR.

Bibliography: Reports XV, XVII, XVIII. Bulletins 67, 91. U. S. Bureau of Mines, Bulletin 92. Eng. & Min. Jour.-Press, Vol. 115, pp. 535–538, Mar. 24, 1923.

Feldspar was produced by five operators in two counties during 1922, to the amount of 4587 tons, valued at $37,109, being a slight increase both in tonnage and value over the output of 1921.

Feldspar production began in California in 1910. The mineral is a constituent of many rocks, but can only be commercially produced from pegmatites where the crystals are large and quite free from impurities. The open-cut quarry method of mining this material is commonly used.

Manufacturers of pottery, chinaware, porcelain, enamel wares, also enamel brick and tile, buy most of the better grades of feldspar produced. They use it in both the body and the glaze of the various grades of ceramic products. In the body it constitutes from 10% to 35%, its value there being due to the fact that it melts during firing at a temperature below the fusing points of the other ingredients and forms a firm bond between the particles of clay and quartz. In glazes the percentage of feldspar used runs from 30% to 50%. Small quantities are used in the manufacture of opalescent glass and scouring soaps, and the more impure material is utilized as chicken grit, in making various brands of roofing, and in emery and corundum wheels where it serves as a binder. Various experiments have been made with potash feldspars in the attempt to extract their potash content for use in fertilizers. The most successful of these has been accomplished through

the medium of cement manufacture, and recovery of the potash as a by-product.

The requirements of the pottery trade demand that in general the percentage of free silica associated with the feldspar be less than 20%, and in some cases the potters specify less than 5%. An important factor, also, is the iron-bearing minerals frequently present in pegmatites and granites, such as biotite (black mica), garnet, hornblende, and black tourmaline. Feldspar for pottery uses should be practically free of these. The white, potash-mica, muscovite, is not particularly objectionable except that, being in thin, flexible plates, it does not readily grind to a fineness required for the feldspar.

A recent paper by Arthur S. Watts,[1] Professor of Ceramic Engineering at Ohio State University, contains much valuable information on the subject of commercial feldspar, and the following paragraphs are quoted therefrom:

"Feldspars may be classified according to their alkali or alkaline earth constituent into four distinct groups: (1) Potash feldspars, known as microcline or orthoclase, $KAlSi_3O_8$; (2) soda feldspar, known as albite, $NaAlSi_3O_8$; (3) lime feldspar, known as anorthite, $CaAl_2Si_2O_8$; (4) barium feldspar, known as celsian, $BaAl_2Si_2O_8$. In nature, these minerals commonly occur as intimately crystallized masses of two or more different feldspars. Some of the feldspars apparently combine and form homogeneous crystals of definite composition, whereas others are isomorphous mixtures.

* * * * * * *

"Mixtures of microcline and albite or mixtures of microcline and albite-rich members of the plagioclase series are really the feldspars with which the manufacturer who uses the material popularly known as "potash feldspar" has to deal.

"In purchasing 'soda feldspar' the manufacturer never obtains pure albite, because deposits of pure albite of commercial size do not exist. The nearest approach to pure albite which is obtainable in commercial quantity is a feldspar high in soda content and relatively low in potash and lime content.

* * * * * * *

"The alkali feldspars are the only ones that have industrial importance at present. The potash feldspars are used in largest quantities. They constitute the chief flux or solvent of all ceramic or clay bodies, causing a gradual vitrification which can be controlled successfully in commercial kilns. These include art and service porcelains, chinas and earthenwares, sanitary porcelains, wall and floor tiles, electrical porcelains, and chemical porcelains. They are also used in compounding glasses, glazes, and metal enamels.

"The soda feldspars are used chiefly as an auxiliary flux with the potash feldspars, but predominate as a glaze flux over the potash feldspar, owing to the fact that they impart to the surface produced a superior gloss and texture.

"Feldspar was marketed to the user in the ground state exclusively until within the last five years, when a few large and particular manufacturers have installed grinding machinery and are now buying the crude rocks.

* * * * * * *

"All feldspar-bearing rocks are of igneous origin—that is, they have solidified from molten masses. The potash and soda feldspars are found chiefly in granites, which generally occur as vast intruded masses, and consist essentially of quartz, feldspars, micas, and hornblende. Granite masses generally contain dikes or sills of rock that are similar in composition to the granite itself, but were intruded after the latter had more or less solidified. These dikes or sills are generally pegmatite—that is, they are coarsely crystalline granite in which feldspar and quartz are the chief constituents; the other granite constituents may be totally absent or replaced by rare minerals. This pegmatite is the source of the feldspar of commerce.

"When the crystallization is exceptionally coarse or the constituents of the dike are separated into distinct bands, it is sometimes possible to obtain feldspar in commercial quantity absolutely free from associate minerals. In most dikes the feldspar and quartz are crystallized too intimately to permit of such a separation, and the most that can be accomplished is the elimination of such associated minerals as are segregated or sufficiently coarsely crystalline.

"Feldspar is mined by ordinary quarry methods, and after a general sorting the rejected portion is resorted and by 'cobbing' an additional yield of marketable rock is obtained. The crude rock is crushed in a jaw crusher or under a buhrstone chaser mill, and screened, the fines going to the pulverizing mill and the coarse material returning for further crushing. The pulverizing process is accomplished in either the ball mill, the tube mill, or the conical mill. In the United States, all grinding is done dry, whereas in Europe where the plants grind their own feldspar, the wet process of grinding is general. (For a full discussion of grinding methods, see Bulletin of February 20, 1922, American Ceramic Society.)

[1] Watts, A. S., The marketing of feldspar: Eng. & Min. Jour.-Press, Vol. 115, pp. 535–538, Mar. 24, 1923.

"Grades of Feldspar.

"No definite grading system has ever been established either in crude or ground feldspar. The terms No. 1 and No. 2 spar are sometimes used in market reports, but these have only general meaning. No. 1 feldspar is a selected grade of the product of the district. No. 2 feldspar is a grade less carefully selected than No. 1 and generally higher in quartz and muscovite. Neither No. 1 nor No. 2 grade feldspar may contain biotite (black mica), garnet or tourmaline in amount sufficient to noticeably affect the color of the feldspar when fused. In some districts a No. 1 grade will carry no free silica, though in other districts the same grade will carry 10 or even 15 per cent quartz. Numerous attempts to reach some agreement between producers and consumers have failed, but the problem is now under consideration by a committee of the American Ceramic Society, and doubtless some system of grading will be offered in the near future.

"A grade known as dental feldspar has been produced and marketed for many years, but the consumption amounts to only a few tons per year and need hardly be considered. It is obtained by carefully hand sorting a quantity of choice, crude feldspar and selecting the perfectly clear crystals free from all foreign material. This is carefully barreled and sold to the manufacturers of artificial teeth.

"Another grade sometimes referred to in reports is that known as soap feldspar. This is purchased by a large producer of scouring soap. It consists of feldspar rock absolutely free from quartz, but containing mica in such quantity as to condemn it for the ceramic market.

"A few feldspar grinders are producing what they call a glaze feldspar. This is a natural or artificial mixture of potash and soda feldspar in about equal proportions, in which the soda feldspar is slightly in excess.

"There is no basis for a grade known as glassmakers' or enamelers' feldspar, as both of these industries are demanding as high-grade potash feldspar as they can secure. The fact that their product is completely fused, however, may cause them to accept or even prefer a coarser-ground product than would be acceptable to the clay-working industries.

"The consumption of ground feldspar is practically uniform throughout the year, and as the mining is regulated in many sections by weather conditions, this necessitates excess production of crude feldspar during the summer months in most localities.

"There is practically no market for feldspar discolored by iron or iron-bearing minerals. The manufacturers of clay wares demand exceptionally finely pulverized product, not more than 6 per cent residue on a 200-mesh sieve. In the glass and enameled metal industries, the requirements are less severe, many consumers accepting material provided it passes 100-mesh sieve.

"There are no standard specifications governing the sale of feldspar. The general requirements are covered, however, by the following specifications:

"I. *The Sample.*

"In sampling carload lots, equal amounts shall be taken from at least five different points in the car, no two samples being taken within five feet of each other.

* * * * * * *

"II. *Chemical Composition.*

"1. Feldspar sold as potash feldspar shall contain not less than 9 per cent K_2O, and not more than 3 per cent Na_2O and not more than 1 per cent CaMgO, and the sum of the potash and soda contents shall not be less than 12 per cent.

"2. Feldspar sold as soda feldspar shall contain not less than 7 per cent Na_2O, not more than 3 per cent K_2O, and not more than 2 per cent CaMgO, and the sum of the potash and soda contents shall not be less than 10 per cent.

"3. Feldspar sold as mixed or blended feldspar shall contain not less than 11 per cent total potash and soda content.

"III. *Physical Properties and Tests.*

"1. Color. The feldspar when formed into a standard-sized cone and deformed in a closed sagger or muffle shall show a uniform white color and no specks or spots either on the surface or on the interior of the cone when broken.

"2a. Fineness of Grain. One hundred grams of the sample, after being dried to constant weight at 105 deg. C., shall be tested for fineness of grain according to the process set forth in paragraph 2b, and the residues on the various standard sieves shall not exceed the maximum totals as set forth in the following table:

"Standard sieve mesh per linear inch	Residues in per cent	
	Each sieve	Maximum total
65	0.25	0.00
100	0.25	0.50
150	1.75	2.25
200	3.75	6.00
250	5.00	11.00
300	7.00	18.00

"All percentages are calculated on dry basis.

* * * * * * *

"3. Moisture Content. Unless otherwise specified, the purchase price shall be based on moisture-free material.

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"4. Fusion Behavior. Test cones of the material shall be made of standard dimensions: i. e., 2⅞ in. high by 9/16 in. diameter across base of one face.

* * * * * * *

"The fusion behavior of the different feldspars shall be as follows:

"(a) Feldspars sold as potash feldspars shall fuse with or prior to Standard Orton cone 8. The mixture of 75 per cent feldspar and 25 per cent standard flint shall fuse with or prior to Standard Orton cone 9.

"(b) Feldspars sold as soda feldspars shall fuse with or prior to Standard Orton cone 7. The mixture of 75 per cent soda feldspar and 25 per cent standard flint shall fuse with or prior to cone 8.

"(c) Feldspar sold as mixed or blended feldspar shall, if it contains more than 4 per cent soda, fuse prior to cone 7. The mixture of 75 per cent mixed or blended feldspar and 25 per cent standard flint shall fuse prior to cone 8.

"5. Shipping Conditions. All material purchased under these specifications shall be shipped in clean, closed cars.

* * * * * * *

"Feldspar is shipped in bulk in carload lots. A common and questionable practice is to merely clean the car carefully and dump the pulverized feldspar directly on the floor. Within the last few years some buyers insist that the car be lined with paper. Less than carload lots are shipped in cloth sacks, which are charged for, but are returnable for credit. All prices are quoted f.o.b. cars at mill.

"No basis for determining the value of feldspar based on its actual composition has been established, and at present a feldspar with 10 per cent potash or soda has the same market value as one containing 12 per cent. Much interest is manifested in the subject, however, and no doubt some radical changes will result within the next year or two.

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"The price of pulverized feldspar per short ton has varied considerably during the last ten years. In 1913 the select, extra fine ground feldspar sold for $13, approximately, per ton, f.o.b. cars at mill in car lots. The cheapest grade, poorly ground, sold at about $10. In 1916 the price had advanced about $2 per ton on all grades. In 1918 the price had reached $20 for first grade and $15 for poorly ground and stained."

The most important recent developments in feldspar deposits in California have taken place in San Diego and Riverside counties, where large deposits of massive, high-grade spar are being opened up. These deposits are unusually free from black mica and other deleterious iron-bearing minerals objectionable in pottery work. The important districts are near Lakeside and Campo in San Diego County, and near Lakeview, Murrietta, and Elsinore, in Riverside County. For 1921, some production was also reported from San Bernardino County; but none in 1922, and none was reported from Monterey and Tulare counties, for the past two years.

Total Feldspar Production of California.

Total amount and value of feldspar production in California since the inception of the industry are given in the following table, by years:

Year	Tons	Value	Year	Tons	Value
1910	760	$5,720	1917	11,792	$46,411
1911	740	4,560	1918	4,132	22,061
1912	1,382	6,180	1919	1,272	12,965
1913	2,129	7,850	1920	4,518	26,189
1914	3,530	16,565	1921	4,349	28,343
1915	1,800	9,000	1922	4,587	37,109
1916	2,630	14,350			
			Totals	43,621	$237,298

FLUORSPAR.

Bibliography: Reports XVII, XVIII. Bulletins 67, 91.

Fluorspar is used as a flux in steel and iron smelting for which use no substitute has yet been found; and in the production of aluminum. It is also utilized in the manufacture of hydrofluoric acid, glass, porcelain, enamels and sanitary ware.

[1]"The market for the bulk of the fluorspar sold in the United States depends on the steel industry, and the demand fluctuates with the rise and fall in the production of steel. Gravel spar is consumed as a flux in basic open-hearth steel furnaces and to a smaller extent in other metallurgical operations. In both 1914 and 1915 the sales of gravel spar constituted between 83 and 84 per cent of the total marketed output of domestic fluorspar, and in 1916 it was nearly 86 per cent. Fluorspar is used also as a flux in iron blast furnaces, iron foundries, and in gold, silver, copper and lead smelters; in the manufacture of fluorides of iron and manganese for steel fluxing and of sodium fluoride for wood preservation[2]; in the manufacture of glass, enameled and sanitary ware, and of hydrofluoric acid; in the electrolytic refining of antimony and lead, and in the production of aluminum. Other miscellaneous uses of fluorspar that have been reported are as a bonding for constituents of emery wheels, for carbon electrodes, in the extraction of potash from feldspar, and in the recovery of potash in Portland cement manufacture. The last use depends on the suitability of calcium fluoride as a reagent for increasing the volatilization of potassium salts from the clinker and the regeneration of the reagent from the dust collected.[3]"

In California, deposits have been reported in Los Angeles, Mono, Riverside and San Bernardino counties, but up to 1917 no commercial production had resulted.

In 1917–1918, a total of 79 tons valued at $991 was shipped from Riverside County, but none since. In 1921, at the King Mine under development near Afton, San Bernardino County, some fluorspar was mined but not shipped. Field examinations have indicated a considerable deposit there of merchantable spar.

The Tariff Act of 1922 places a duty of $5.60 per ton on foreign importations of fluorspar.

Present quotations (Engineering and Mining Journal-Press, New York, June 2, 1923) are: Fluxing gravel, 85% calcium fluoride, and not over 6% silica, @ $21 per ton; acid lump $35; No. 2 lump, $30; f. o. b. Illinois mines. Lump, 92%, at $17, f. o. b. New Mexico.

FULLER'S EARTH.

Bibliography: Reports XIV, XVII, XVIII. Bulletins 38, 91. U. S. Bureau of Mines, Bulletin 71.

Fuller's earth includes many kinds of unctuous clays. It is usually soft, friable, earthy, nonplastic, white and gray to dark green in color, and some varieties disintegrate in water. Like all other clays, fuller's earth is a hydrous aluminum silicate, but usually contains a higher percentage of water of composition than most clays. This water is

[1]Burchard, E. F., Fluorspar and cryolite in 1916: U. S. Geol. Surv., Min. Res. of U. S., 1916, Part II, p. 315, 1917.

[2]Teesdale, C. H., Use of fluorides in wood preservation: Wood Preserving, vol. 3, No. 4; vol. 4, No. 1. (Reprint, 9 pp.)

[3]Treanor, John, Potash from cement at the Riverside Portland Cement Co.: Met. and Chem. Eng., June 15, 1917, pp. 701–703.

not an essential factor in the bleaching properties of all fuller's earths, as some bleach fully as well after it has been driven off as before, and others lose much of their bleaching power when this water is removed. All fuller's earths which have been found valuable for bleaching purposes show a distinctly so-called 'acid reaction.' (If a sample is touched to neutral litmus paper the paper will be turned red). Chemical analyses are now well understood to be no criterion in determining the classification of a given clay as 'fuller's earth.' *The final determination is a commercial one as to its capacity for absorbing basic colors and removing these colors from solution in animal, vegetable or mineral oils, also from water.*

[1]"The Shipping Board's Inquiries also brought out the interesting information that only domestic fuller's earth is used for the refining of mineral oils. There appears, on the other hand, to be a difference of opinion as to the suitability of the domestic earth for use in refining edible oils. Some of the larger users of fuller's earth, anticipating a shortage of imported material, began early in the war to experiment with domestic earths in refining edible oils and fats, with results so satisfactory that they became independent of imported earth. Others stated that they had experimented with every known domestic earth, but had not found one that completely met the requirements to supplant the imported earth. The requirements of a good earth for refining edible oils are (1) that it shall bleach well and that the oil shall not revert to its original color; (2) that it shall filter well and not cake badly; (3) that it shall leave no permanent disagreeable taste or odor; (4) that the retention of oil in the spent earth shall be small; and (5) that there shall be no spontaneous ignition either in the press or in the waste piles. Those who use the imported earth claim that it is standard in all of these requirements, and that the domestic earth is deficient in one or more of them. Such a defect as inability to bleach well appears to be inherent in some domestic earth, and can not be remedied by treatment. Other defects, such as the taste or odor left by the earth, which is the most frequent objection urged against the domestic material, may possibly be overcome by treatment. Another serious fault charged against the American earth is that it retains a greater proportion of oil than the English earth, which means a direct loss in production; also that it clogs the filter presses more, so that they require more frequent cleaning, which causes further decrease in production. It is also charged that domestic earth is more subject to spontaneous combustion."

In California, fuller's earth has been used in clarifying both refined mineral and vegetable oils, and for special chemical purposes; although its original use was in fulling wool, as the name indicates.

Production has come mainly from Calaveras and Solano counties. Deposits have also been found in Riverside, Fresno, Inyo, and Kern counties. Some of the large oil refiners have been trying out clays of the montmorillonite and halloysite group ('rock soap') to determine their suitability, or efficacy as a substitute for fuller's earth in the refining of petroleum products. Deposits of this class of material are being exploited in Inyo, San Bernardino, and San Diego counties, and occurrences have been noted in several other counties of California.

The production of 6,606 tons, valued at $48,756, here credited to 1922, as 'fuller's earth' is in reality a colloidal clay of the montmorillonite class ('bentonite', 'otaylite', 'elkonite', 'shosshonite', are merely local names arbitrarily applied to varieties of this mineral found in a given locality). Because it was used for clarifying and filtering processes, we have placed it, for the purposes of this statistical report, under the 'fuller's earth' heading. As noted above, the final determination as to what constitutes a fuller's earth is a commercial one.

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[1]Middleton, Jefferson, Fuller's Earth in 1918: U. S. Geol. Surv., Min. Res. of U. S. 1918. Part II, p. 136. 1919.

Fuller's Earth Production of California, by Years.

Fuller's earth was first produced commercially in this state in 1899, and the total amount and value of the output since that time are as follows:

Year	Tons	Value	Year	Tons	Value
1899	620	$12,400	1912	876	$6,500
1900	500	3,750	1913	460	3,700
1901	1,000	19,500	1914	760	5,928
1902	987	19,246	1915	692	4,002
1903	250	4,750	1916	110	550
1904	500	9,500	1917	220	2,180
1905	1,344	38,000	1918	37	333
1906	440	10,500	1919	385	3,810
1907	100	1,000	1920	600	6,000
1908	50	1,000	1921	1,185	8,295
1909	459	7,385	1922	6,606	48,756
1910	340	3,820			
1911	466	5,291	Totals	18,987	$226,199

NOTE.—Above production, in 1922, was montmorillonite (hydrous aluminum silicate) a colloidal clay, sometimes called 'rock soap,' and in part locally called 'shoshonite' from its being found near Shoshone in Inyo County; and in part 'otaylite' from Otay, San Diego County.

GEMS.

Bibliography: State Mineralogist Reports II, XIV, XV, XVII, XVIII. Bulletins 37, 67, 91. U. S. G. S., 'Mineral Resources of the U. S.'; Bull. 603, p. 208. Bull. Dept. Geol. Univ. of Cal., Vol. 5, pp. 149–153, 331–380. Am. Jour. Sci., Vol. 31, p. 31.

The production of gem materials in California has been somewhat irregular and uncertain during the past ten years. The compilation of complete statistics is difficult owing to the widely scattered places at which stones are gathered and marketed in a small way. The higher figure of the year 1920 was due to shipments of quartz crystals from Calaveras County and Iceland spar from Modoc County sold for optical purposes, which use demands material of gem quality and free from flaws. The tourmaline mines at Pala, San Diego County, are being reopened, so there is promise of an increased production for 1923.

The following table shows the production, by counties, of rough, uncut gem and jeweler's materials during 1922:

County	Value	Kind
Butte	$225	Diamonds
San Diego	400	Tourmaline, blue and green topaz
Calaveras, Riverside, San Bernardino, Sonoma	*687	Quartz crystals, Optical fluorite[1], Thomsonite and sapphire, Chalcedony
Total value	1,312	

*Combined to conceal output of a single operator in each.
[1]Mined and sold in 1918, but not reported to State Mining Bureau till 1922.

Varieties of California Gem Stones.

Diamonds have been found in a number of localities in California; but in every case, they have been obtained in stream gravels while working them for gold. The principal districts have been: Volcano in Amador County; Placerville, Smith's Flat and others in El Dorado

County; French Corral, Nevada County; Cherokee Flat, Morris Ravine, and Yankee Hill, Butte County; Gopher Hill and upper Spanish Creek, Plumas County. The most productive district of recent years has been Cherokee in Butte County.

California *tourmalines* are decidedly distinctive in coloring and 'fire' as compared to foreign stones of this classification. The colors range from deep ruby to pink, and various shades of green; also a blue tourmaline has been found.

One of our California gem stones, *benitoite*, has not been found elsewhere; and in but a single locality here: The Dallas Mine in San Benito County.

Kunzite, a gem variety of spodumene, was first found in the Pala district in San Diego County. It has thus far been found in only one locality (Madagascar) outside of California. It is of a lilac color, and is described in detail in Bulletin 37 of the State Mining Bureau.

Beryls of excellent fire and delicate colors are also obtained in the Pala district, of which the *aquamarine* (blue) and *morganite* (pink) varieties deserve special mention. Morganite, like kunzite, has thus far been found elsewhere only in Madagascar.

Californite, or 'California jade,' is a gem variety of vesuvianite, and is green or white in color. It is found in Butte, Fresno, and Siskiyou counties.

Some *rhodonite* has been mined in Siskiyou County, and used for decorative purpose, its value being included in the marble figures.

Chrysoprase has been produced in Tulare County.

Turquoise has been found in the desert section of San Bernardino County, but none produced commercially in recent years.

Sapphires have been reported recently found in San Bernardino and Riverside counties, but not as yet confirmed.

Rubies have been identified by the laboratory of the State Mining Bureau, occurring in limestone from the Baldy Mountains, San Bernardino County. Thus far no stones of commercial size have been taken out.

Total Production of Gem Materials in California.

The value of the gem output in California annually since the beginning of commercial production is as follows:

Year	Value	Year	Value
1900	$20,500	1912	$23,050
1901	40,000	1913	13,740
1902	162,100	1914	3,970
1903	110,500	1915	3,565
1904	136,000	1916	4,752
1905	148,500	1917	3,049
1906	497,090	1918	650
1907	232,642	1919	5,425
1908	208,950	1920	36,056
1909	193,700	1921	10,954
1910	237,475	1922	1,312
1911	51,824	Total	$2,145,804

Industrial Uses of Precious Stones.

The following enumeration of the industrial applications of precious stones is quoted from 'Mineral Resources of the United States'[2]:

"Some Industrial Uses of Precious Stones.

"In the following paragraphs are given some industrial uses of minerals of gem quality. In addition to ornamentation, all gem minerals are of value as specimens for collections, for use in standardization (for example, fluorite and quartz as standards of densities and of refractive indices), and as sources of material for investigation, both industrial and scientific. These uses are therefore not always repeated under the different mineral names. Ornamentation itself covers a variety of utilization, such as for jewelry, knife handles, paper weights, and pipes (meerschaum).

"*Agate.* Mechanical bearings and supports, scale bearings, balls for water meters.

"*Azurite.* Ore of copper; pigment for paint.

"*Azurmalachite.* Ore of copper.

"*Calcite.* See Iceland spar.

"*Chromite.* Ore of cromium.

"*Chrysocolla.* Ore of copper.

"*Cobaltite.* Ore of cobalt.

"*Corundum.* See Sapphire.

"*Diamond.* Cutting, grinding, engraving, boring, and polishing material; supports for bearings and pivots; dies for wire drawings; tips for phonograph needles.

"*Epidote.* For coloring artificial slate and roofing material.

"*Fluorite.* See Optical fluorite.

"*Franklinite.* Ore of manganese and zinc.

"*Garnet.* Abrasive; for watch jewels or jeweled bearings; as tared weights.

"*Garnierite.* Ore of nickel.

"*Gypsum.* Used in manufacture of artificial pearls—the so-called "Roman pearls."

"*Hematite.* Ore of iron.

"*Iceland spar.* Iceland spar is a variety of calcite, clear and transparent and unusually free from imperfections and impurities. Transparent crystals or cleavage pieces of calcite of any appreciable size are very rare, and as Iceland has furnished almost all of such material used, the name Iceland spar has been given it.

"Elongated cleavage rhombohedrons of Iceland spar are used in the manufacture of nicol prisms, which are an essential part of optical instruments requiring plane polarized light, as, for example, certain microscopes, dichroscopes, and saccharimeters. The material, on account of its simple chemical composition and purity, finds application in chemical standardization. Iceland spar is also used in the manufacture of some kinds of glass, and some of it is sold as mineral specimens.

"Pieces of Iceland spar, either in single untwinned crystals or parts of such crystals, or in homogeneous untwinned cleavage rhombohedra, which are large enough to yield a rectangular prism at least one inch long and half an inch thick each way and which possess the properties described below, are suitable for optical purposes. The colorless material must be so clear and transparent that it is limpid and pellucid. It must not be partly opaque on account of numerous cracks or fractures, must not show any internal, iridescent, or rainbow colors due to incipient cracks along fracture lines, nor any cleavage, nor twinning planes. Neither can there be any capillary or larger tubelike cavities, nor cavities or bubbles of any shape, nor inclusions, as isolated particles, veins, or clouds, composed of minute crystals of some other mineral or of any kind of foreign substance. The spar should not be discolored or stained by the presence of any clay, iron oxide, or other material. It should be noted that many of the inclusions and imperfections of Iceland spar are not always scattered irregularly through the mineral or even segregated in distinct masses, but frequently lie in a distinct but very thin plane which can hardly be seen if looked at on edge. In examining a piece of Iceland spar for defects the piece should therefore be turned in all directions while held to the light.

"The material suitable for optical uses naturally brings the highest prices, as it has to be at least of the dimensions already given. Specimen material is generally of a larger size. The material used for standardization, chiefly chemical, need be of no special size, and the smaller pieces are as usable as the larger ones.

"The optical variety of Iceland spar produced in the United States, sold, per pound, for $3 to $4 in 1914, about $8 in 1915, and as high as $20 in July, 1918. The specimen variety sells for considerably less, and material for standardization sells for from $1 to $2 a pound.

"The following firms are buyers of Iceland spar suitable for optical use: Bausch & Lomb Optical Co., Purchasing Department, Rochester, N. Y.; Central Scientific Co., 460 Ohio street east, Chicago, Ill.; Gilbert S. Dey, Superintendent Optical Department, Eastman Kodak Co., Rochester, N. Y.

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[2]Schaller, W. T., Gems and precious stone in 1918: U. S. Geol. Surv., Min. Res. of U. S., 1918, Part II, pp. 12–14, 1919.

"The market for specimen spar is irregular, as the demand is usually very light. The best market will probably be found with some of the larger mineral dealers.

"Standardization material may be sold to large dealers in general chemicals as well as to mineral dealers.

"Although calcite is, next to quartz, the commonest mineral, the only locality[3] outside of Iceland known to produce the variety Iceland spar in commercial quantity is in Montana, about 9 miles from Gray Cliff, Sweet Grass County, on the main line of the Northern Pacific Railway. The spar occurs in a nearly vertical fissure vein from 3 to 8 feet thick, which strikes northwest, traversing a gneissic rock for several miles.

"Brief mention of the Montana occurrence of Iceland spar is made in the reports on the production of gems and precious stones in Mineral Resources for 1913 (p. 704) and 1914 (p. 335). C. L. Parsons, of the Bureau of Mines, has also described the occurrence and material in Science, Vol. 47, No. 1221, pp. 508–509, May 24, 1918.

"*Jasper.* See Agate.

"*Malachite.* Ore of copper, pigment for paint.

"*Mariposite.* Pigment for paint.

"*Meerschaum.* Pipe bowls; cigar and cigarette holders.

"*Optical fluorite.* Fluorite, commonly called fluorspar, is a common mineral but is very seldom found in pieces clear enough and large enough to be of special use in the manufacture of certain optical lenses and prisms. Fluorite of the requisite qualities as described below, suitable for such use, is known as 'optical fluorite.' Any deposit of fluorite may yield a small quantity of such material, but at present about the only localities known to produce it are southern Illinois, Meiringen, Switzerland; and Obira, Bungo, Japan. Optical fluorite is cut into lenses and placed between glass lenses. It forms the apochromatic objective for microscopes and similar optical instruments, the fluorite lens correcting the spherical and chromatic errors of the glass lens systems. This result is due to the low refractive power, weak color dispersion, and single refraction of fluorite. These apochromatic lenses represent the finest type of microscope objectives made. The use of such a fluorite lens greatly increases the value of a microscope and if optical fluorite were more abundant many more microscope objectives would be equipped with such lenses.

"Optical fluorite is also used in the lenses of certain telescopes, in making prisms for spectrographs in ultra-violet work, and in other optical apparatus where transparency in the ultra-violet and infrared parts of the spectrum is necessary.

"Optical fluorite must yield or contain pieces at least one-fourth of an inch in diameter, which must be clear and colorless and free from all defects. Defects consist of internal cracks or cleavage planes, bubbles, or inclusions of dirt or mineral matter. The presence of faintly developed or incipient cleavage planes or fracture surfaces usually may be determined, if not readily visible, by moistening the specimen with kerosene. The material must not show any anomalous double refraction. Absolutely water-clear material is of the highest value, but very faint tints of green, yellow, or purple do not render the material useless.

"Fluorite suitable for optical use is valued at from $1 to $10 a pound, according to the size of the piece suitable for cutting as well as to its quality. The present yearly requirement is not large—perhaps several hundred pounds—but under proper conditions and with a dependable steady supply this requirement may be increased.

"Possible buyers of optical fluorite are: Bausch & Lomb Optical Co., Rochester, N. Y.; Spencer Lens Co., Buffalo, N. Y.; Ward's Natural Science Establishment, Rochester, N. Y.; United States Bureau of Standards, Washington, D. C.

"Suitable material has been obtained from several of the fluorite mines in Hardin County, Ill., and may also occur in the extension of this fluorite belt in western Kentucky. Although fluorite is found in many other states, practically none of them is known to contain any 'optical fluorite.'[4]

"Among publications dealing with optical fluorite are the following:

"Pogue, J. E., Optical fluorite in southern Illinois: Separate from Bull. 38, Illinois State Geol. Survey, Urbana, Ill., 1918.

"Burchard, E. F., Fluorspar and cryolite in 1917: U. S. Geol. Survey, Mineral Resources, 1918, pt. 2, pp. 301–302, 1918.

"U. S. Bureau of Standards, Washington, D. C.: Circular letter dated May 8, 1918.

"*Quartz.* See Rock crystal.

"*Rock crystal.* The perfectly clear and colorless variety of quartz is called rock crystal. It furnishes the material for certain special glasses and fused silica ware; and it is used in wedges for microscopic work, as spectographic prisms for special researches, and as mechanical bearings. A use in connection with certain sounding boxes has recently been developed.

"*Sepiolite.* See Meerschaum.

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[3]Since the above was written, there has been some production of optical Iceland spar from Modoc County, California.

[4]A small amount of optical fluorite was reported sold in 1918 from material mined in Riverside County, California.

"*Sapphire.* The variety of gem corundum used for other purposes than jewelry is called sapphire, irrespective of its color. It is used for mechanical bearings and pivot supports, especially in watches and phonograph needles (mostly artificial sapphire).

"*Topaz.* Abrasive.

"*Tourmaline.* In the tourmaline tongs or in polarizing forceps, a very simple form of polariscope."

GRAPHITE.

Bibliography: State Mineralogist Reports XIII, XIV, XV, XVII. Bulletin 67. U. S. G. S., Min. Res., 1914, Pt. II.

Graphite has been produced from time to time in the state, coming principally from Sonoma and Los Angeles counties. It is difficult for these deposits, which must be concentrated, to compete with foreign supplies, which go on the market almost directly as they come from the deposit. Graphite ores are concentrated with considerable difficulty, and the electric process of manufacturing artificial graphite from coal has been perfected to such a degree that only deposits of natural graphite of a superior quality can be exploited with any certainty of success.

According to the U. S. Geological Survey, operators in this country who are working disseminated flake deposits must depend on their No. 1 and 2 flake for their profit. Graphite dust is merely a by-product and is salable only at a low price. Improved methods of graphite milling adopted promise to increase largely the production of flake of better grade.

The principal value of graphite is on account of its infusibility and resistance to the action of molten metals. It is also largely used in the manufacture of electrical appliances, of 'lead' pencils, as a lubricant, as stove polish, paints, and in many other ways. Amorphous graphite, commonly carrying many impurities, brings a much lower price. For some purposes, such as foundry facings, etc., the low-grade material is satisfactory. Among the newer uses for graphite is the prevention of formation of scale in boilers. The action is a mechanical one. Being soft and slippery, the graphite prevents the particles of scale from adhering to one another or to the boiler and they are thus easily removed.

The price increases with the grade of material, the best quality crystalline variety being quoted at present at 6¢–6½¢ per pound (Ceylon lumps); with American flake at 4¢–5¢ per pound f.o.b. mine.

The coarser flakes are necessary for crucibles, as they help to bind the clay together in addition to their refractory service. Since the close of hostilities in Europe, prices have declined to pre-war levels; and imports have been resumed from Ceylon, Canada, Madagascar, Mexico and Korea, of a total of 7496 tons valued at $452,076 in 1921.

Occurrence of graphite has been reported at various times from Calaveras, Fresno, Imperial, Los Angeles, Mendocino, San Bernardino, San Diego, Siskiyou, Sonoma and Tuolumne counties.

During 1922 an increased production was reported from Los Angeles County. It was concentrated from a disseminated ore, and was used

for paint and foundry facing. As there was but a single operator, the figures are concealed under the 'Unapportioned' item. The production, by years, has been as follows:

Year	Pounds	Value
1901	128,000	$4,480
1902	84,000	1,680
1903		
1913	2,500	25
1914		
1915		
1916	29,190	2,335
1917–1920	*770,000	37,225
1921–1922	*624,000	26,160
Totals	1,637,690	$71,905

*Annual details concealed under 'Unapportioned,' on account of a single producer.

GYPSUM.

Bibliography: Reports XIV, XV, XVII, XVIII. Bulletins 38, 67, 91. U. S. Geol. Surv., Bull. 223, 413, 430, 697.

Gypsum is widely distributed throughout the state, and has been produced to some extent, to supply fertilizer manufacturers as well as those of plaster and cement.

During 1922, producers in Imperial and San Bernardino counties took out a total of 47,084 tons, valued at $188,336, compared with 37,412 tons, valued at $78,875 in 1921.

Uses.

The most important use of gypsum is in the calcined form where it is utilized in the manufacture of various hard-wall plasters and plaster board. As plaster of paris, it plays a very important part in surgical work. Approximately 2% of raw gypsum is added in the manufacture of Portland cement just before the final grinding. In this application, the gypsum acts as a retarder to the set of the cement.

During the past year about 76% of the total gypsum mined in the United States went into the manufacture of gypsum plasters of various brands.[1] The increased use of this plastering material has encouraged the formation of new concerns at a number of localities throughout the country, one of which is in Imperial County, California. The use of gypsum tile for nonbearing fireproof partitions, stairway and elevator enclosures, and the protection of steel columns, girders and beams, has increased to an extent to justify the construction of new plants and machinery at the manufacturers' mills.

"Similar advances are noted in respect to the use of gypsum plaster board and gypsum wall board in building construction. Gypsum plaster board, recognized as an incombustible lathing material, is in great demand for nonbearing incombustible partitions in fireproof construction when secured to metal supports and covered with gypsum plaster. More recent uses of gypsum plaster board include suspended ceilings, insulation and fire protection. This material is also being used upon the roof boards and under wood shingles, and between the wood sheathing and finished siding for fire protection purposes and insulation.

[1]Marani, V. C., Gypsum industry's growth in 1922: Rock Products, Vol. XXV, p. 53, Dec. 30, 1922.

"The scarcity of plasterers has contributed to a substantial increase in the use of gypsum wall boards which constitute an interior wall, ceiling and partition finish for all types of buildings. The popular desire for an interior finish of this character which is incombustible has necessitated provisions for a greater output and a standardized product. Manufacturers of this product have increased their plant facilities, and have included such mechanical changes in the machinery as will assure a product of uniform strength and thickness. Gypsum boards are manufactured to meet the fire test and requirements of the Underwriters' Laboratories, Inc., and in conformity with the strength and dimension specifications of the American Society for Testing Materials.

"Building construction economics, which involve consideration of 'dead load' to be provided for, rapid erection, quick setting, etc., have contributed to the prevailing use of reinforced gypsum in the construction of fireproof floors and roofs. The improvements during the past years in this type of construction are noticeable in the character and method of reinforcing, a more dense and uniform product and, in the case of precast structural tile or slabs, joint details which assure more satisfactory results and provide for any unequal spacing of the steel supports.

"More recent developments in the use of gypsum for floor or roof construction in one instance involve the use of standard rolled steel sections designed to carry the full load. The construction is completed by attaching precast reinforced gypsum slabs on top to form the floor and below for the ceiling.

"Another new roof construction consists of steel supports between which a gypsum plaster board is set (as a form) over which the reinforcement is placed, the whole being covered with the gypsum, which is poured-in-place. The plaster board form is not removed. The importance of gypsum floor and roof constructions, aside from the fire protection afforded, lies in the weight, which in some designs is only 48 lb. to the cubic foot.

"A better knowledge of the chemical and physical properties of calcined gypsum has made possible the use of gypsum, in the form of tile, as a void filler in combination systems in which reinforced concrete T-beams are designed to carry the full 'dead' and 'live' loads. The light weight of gypsum permits the use of a larger void filler than usual and, consequently, greater spacing of the concrete beams. In work involving about 50,000 sq. ft. or more it is practicable to cast the gypsum tile on the job.

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"Its Use for Insulation Purposes.

"The use of gypsum for purely insulation purposes is being fostered by American enterprise. A new, economical and practical process consists of introducing into the calcined gypsum when mixing certain chemicals in powdered form up to a possible 7 per cent of the bulk. The resultant chemical action just prior to the setting period causes the mass to increase from two to three times its original bulk, yielding an extremely porous material of cellular formation which, according to the amount of chemical uses, can be made to weigh as little as 9 lb. to the cubic foot. Because this material sets quickly it can be poured in place, or in forms, for the purpose desired. The logical field for this material will be the insulation of dwelling-house exterior walls and the ceilings and attics."

Gypsum plaster is used as a binder in molding carborundum grinding wheels. The common blackboard crayon known as 'chalk' is made of finely pulverized raw gypsum to which a binder has been added; and for colored crayons a pigment is also added.

The action of gypsum as a fertilizer was formerly considered to be indirect[2]; that it was not a food for plants, but was supposed to act on the double silicate of magnesia and potash in the soil, freeing the magnesia and potash, so that they become available as plant food. Its use was believed to be beneficial only if these elements are present in the soil. More recently, investigations are stated to prove that gypsum serves as a source of both sulphur and calcium, which are plant foods.

Some authorities hold that land plaster tends to make nonporous clay soils more pervious to water and to make sandy soils less pervious. Ground gypsum has an affinity for water and will draw moisture from the atmosphere, so it keeps moisture in the soil and is of value to the farmer who is starting grain and grass crops, as it holds moisture where the roots of the small plants most need it. The use of ground gypsum or land plaster in a dry, hot season may draw enough moisture from the atmosphere to save a crop from damage by drought. Land plaster is employed to neutralize the black alkali that forms in many of the soils of arid regions, as in parts of California, Nevada and Utah.

[2]U. S. G. S. Press Bulletin No. 371, July, 1918, p. 4.

Land plaster may be applied to the soil by drilling, or scattered in the hill, or it may be sowed broadcast, in quantities ranging from 200 to 500 pounds to the acre.

Total Production of Gypsum in California.

Production of gypsum annually in California since such records have been compiled by this Bureau is as follows:

Year	Tons	Value	Year	Tons	Value
1887	2,700	$27,000	1906	21,000	$69,000
1888	2,500	25,000	1907	8,900	57,700
1889	3,000	30,000	1908	34,600	155,400
1890	3,000	30,000	1909	30,700	138,176
1891	2,000	20,000	1910	45,294	129,152
1892	2,000	20,000	1911	31,457	101,475
1893	1,620	14,280	1912	37,529	117,388
1894	2,446	24,584	1913	47,100	135,050
1895	5,158	51,014	1914	29,734	78,375
1896	1,310	12,580	1915	20,200	48,953
1897	2,200	19,250	1916	33,384	59,533
1898	3,100	23,600	1917	30,825	56,840
1899	3,663	14,950	1918	19,695	37,176
1900	2,522	10,088	1919	19,813	50,579
1901	3,875	38,750	1920	20,507	92,535
1902	10,200	53,500	1921	37,412	78,875
1903	6,914	46,441	1922	47,084	188,336
1904	8,350	56,592			
1905	12,859	54,500	Totals	594,642	$2,166,672

INFUSORIAL and DIATOMACEOUS EARTH.

Bibliography: State Mineralogist Reports II, XII, XIII, XIV, XV, XVII, XVIII. Bulletins 38, 67. Am. Inst. Min. Eng., Bull. 104, August, 1915, pp. 1539-1550. U. S. Bur. of Mines, Rep. of Investigations: Serial No. 2431, Jan., 1923. Eng. & Min. Jour.-Press, Vol. 115, pp. 1152–1154, June 30, 1923.

Infusorial and diatomaceous earths—sometimes called tripolite—are very light and extremely porous, chalk-like materials composed of pure silica (chalk, being calcareous) which have been laid down under water and consist of the remains of microscopical infusoria and diatoms. The former are animal remains, and the latter are from plants. The principal commercial use of this material is as an absorbent. It is also employed in the manufacture of scouring soap and polishing powders; for filtration purposes; in making some classes of refractory brick; and as an insulating medium both in heating and refrigeration. It is a first-class nonconductor of heat, where high temperatures are employed, such as around steel and gas plants and power houses. In such cases, it is built in as an insulating layer in furnace walls. In Germany, under the name 'kieselguhr,' it was used as an absorbent for nitroglycerine in the early manufacture of dynamite.

As a nonconductor of heat it has been used alone or with other materials as a covering for boilers, steam pipes, and safes and in fireproof

cements. It is used largely by paint manufacturers as a wood filler. Boiled with shellac it is made into records for talking machines. It has been used for absorbing liquid manures so that they could be utilized as fertilizers, and as a source of silica in making water-glass as well as in the manufacture of cement, tile glazing, artificial stone, ultra-marine and other pigments of aniline and alizarine colors, paper filling, sealing wax, fireworks, hard-rubber objects, matches, and papier maché, and for solidifying bromide. For making insulating brick the material is sawed into blocks, and for all other purposes it is ground and screened.

The most important deposits in California thus far known are located in Monterey, Orange, San Luis Obispo, and Santa Barbara counties. The Santa Barbara material is diatomaceous and is of a superior quality. Infusorial earth is also found in Fresno, Kern, Los Angeles, Plumas, San Benito, San Bernardino, San Joaquin, Shasta, Sonoma, and Tehama counties.

The following description of the deposit and plant of the Celite Products Company at Lompoc, Santa Barbara County, is quoted from a recent paper published by the U. S. Bureau of mines:[1]

"The character of the material varies in different parts of the bed and only selected parts where the overburden is light, are quarried. Also, certain parts of the bed are used for specific purposes. After cleaning off the overburden, the diatomaceous earth is quarried by means of a channeling machine developed by the company. Cuts are made across the face 4 feet deep and 4 feet apart. The largest part of the production is used for insulating brick, which are sawed on the ground from the blocks cut by the channeling machines. The machine used for sawing the brick was also developed by the company. The material desired for grinding is quarried, after channeling, by pick and shovel and loaded by hand into horse-drawn wagons and then hauled to a drying yard. The brick are hauled to a drying yard in light tram cars. After sun-drying, the brick are hauled to the railroad, and the other product to the mill in motor trucks.

"At the mill, the sun-dried diatomaceous earth is fed by hand into a nimpact pulverizer, which is moved along the bottom of the storage bin. The pulverized material is drawn through galvanized iron tubing by an exhaust fan to the main building where it is packed for shipment in bags. The unbroken single diatoms are desired for filtering and some other uses. The dust, consisting of the finer particles and broken diatoms, which does not settle in the bins of the main building, is drawn into a bag house where it is filtered out of the air. This material is used for polishes and other similar purposes. All crushing is done dry.

"The Kieselguhr is nearly pure silica and has the capacity of absorbing several times its weight of liquids. Dr. Herbert Insley, petrologist, U. S. Bureau of Mines, examined some of the samples under the microscope and made the following report: 'This material is very light in weight due in part to its great porosity. Under the microscope, the material was found to be made up almost wholly of the tests or skeletons of diatoms. These tests are composed of practically pure silica. The silica is evidently amorphous for there is no evidence of double refraction between crossed nicols. Most of the skeletons were unbroken. Complete skeletons more than three-tenths of a millimeter in greatest dimension were not observed, although some of the skeletons of which fragments were observed must have been at least seven-tenths of a millimeter in length. Disk-like diatoms containing hexagonal perforations or depressions and long, slender spine-like diatoms are very common.'

"Photomicrographs made by Dr. Insley show considerable fine dust and many sharp-edged particles.

"The deposit is damp when first exposed, but during the summer months, the air is very dry and the wind blows almost continuously, hence the surface is soon dried. Since the kieselguhr is very light, the dust is easily picked up by the wind."

As over 95 per cent of the output in California is from a single operator, we have concealed the exact figures under the 'Unapportioned' item in the state and county totals. There were three operators in 1922 in San Luis Obispo and Santa Barbara counties.

[1]Gardner, E. D., Mining diatomaceous earth at Lompoc, California: U. S. B. of M., Reports of Investigations Serial No. 2431, Jan. 1923.

Total Production of Diatomaceous Earth in California.

The first recorded production of these materials in California occurred in 1889; total amount and value of output, to date, are as follows:

Year	Tons	Value	Year	Tons	Value
1889	39	$1,335	1907	2,531	$28,948
1890			1908	2,950	32,012
1891			1909	500	3,500
1892			1910	1,843	17,617
1893	50	2,000	1911	2,194	19,670
1894	51	2,040	1912	4,129	17,074
1895			1913	8,645	35,968
1896			1914	12,840	80,350
1897	5	200	1915	12,400	62,000
1898			1916	15,322	80,649
1899			1917	24,301	127,510
1900			1918	35,963	189,459
1901			1919	40,200	217,800
1902	422	2,532	1920	60,764	1,056,260
1903	2,703	16,015	1921, 1922	*90,739	1,016,675
1904	6,950	112,282			
1905	3,000	15,000			
1906	2,430	14,400	Totals	330,971	$3,151,296

*Annual details concealed under 'unapportioned.'

LIMESTONE.

Bibliography: State Mineralogist Reports IV, XII, XIII, XIV, XV, XVII, XVIII. Bulletins 38, 91. Oregon Agr. College, Extension Bulletin 305.

Limestone was produced in nine counties during 1922, to the amount of 84,382 tons, values at $282,181, being a slight increase in tonnage but a decrease in value from the 1921 output of 75,921 tons, worth $305,912.

The amount here given does not include the limestone used in the manufacture of cement, nor of lime for building purposes; but accounts for that utilized as a smelter and foundry flux, for glass and sugar making, and other special, chemical and manufacturing processes. It also includes that utilized for fertilizers (agricultural 'lime'), 'roofing gravel,' paint filler, whiting for paint, putty, kalsomine, terrazzo, paving dust, concrete filler, chicken grit, carbon dioxide gas, 'paving compound,' and facing dust for concrete pipe. That indicated in the table below as coming from Santa Clara County is a calcareous marl sold for agricultural purposes. Of the total product in 1922, approximately 25,000 tons valued at $104,700 was used for agricultural purposes.

In agriculture, the chief reason for the use of lime is now recognized to be that of correcting soil acidity. Lime in stated to be especially necessary for the proper development of the bacteria in the nodules on the roots of legumes such as the clovers and alfalfa. It will also combine with some of the plant food materials already in the soil to make them more readily available, and will supply any lack of calcium

as a plant food that may exist in the soil. To some extent, certain forms of lime will make heavy soils more friable, thus aiding aeration, cultivation and drainage. It may be applied, ground, in either the burned or unburned form, or as hydrated lime.

Distribution of the 1922 output was as follows:

County	Tons	Value
El Dorado	42,200	$113,709
Los Angeles	12,096	35,168
San Bernardino	2,200	7,800
Santa Cruz	4,581	20,534
Contra Costa, Inyo, Santa Clara[1], Siskiyou, Tulare*	23,305	104,970
Totals	84,382	$282,181

*Combined to conceal output of a single operator in each.
[1]Calcareous marl, used for fertilizer.

Limestone Production of California, by Years.

The following tabulation gives the amounts and value of 'industrial' limestone produced in California by years since 1894 when compilation of such records was begun by the State Mining Bureau. These tonnages consist principally of limestone utilized for flux, glass and sugar making, agricultural, chemical, and other special industrial purposes. That utilized in cement manufacture is not included.

Year	Tons	Value	Year	Tons	Value
1894	15,420	$19,275	1910	684,635	$581,208
1895	71,355	71,690	1911	516,398	452,790
1896	68,181	71,112	1912	613,375	570,248
1897	36,796	38,566	1913	301,918	274,455
1898	27,686	24,548	1914	572,272	517,713
1899	30,769	29,185	1915	146,324	156,288
1900	32,791	31,532	1916	187,521	217,733
1901	76,937	99,415	1917	237,279	356,396
1902	71,422	90,524	1918	208,566	456,258
1903	125,919	163,988	1919	88,291	248,145
1904	40,207	87,207	1920	90,120	298,197
1905	192,749	323,325	1921	75,921	305,912
1906	80,262	162,827	1922	84,382	282,181
1907	230,985	406,041			
1908	273,890	297,261	Totals	5,520,050	$7,053,964
1909	337,676	419,921			

LITHIA.

Bibliography: State Mineralogist Reports II, IV, XIV. Bulletins 38, 67.

Lithia mica, lepidolite (a silicate of lithium et al.) utilized in the manufacture of artificial mineral water, fireworks, glass, etc., has been mined in San Diego County since 1899, except between 1905 and 1915. Some amblygonite, a lithium phosphate, has also been obtained from pockets associated with the gem tourmalines. In 1922 there was a slight drop in the yield of lepidolite, the output being utilized in glass manufacture. As there was only a single producer, the figures are concealed under the 'unapportioned' item. The average value reported was $15.30 per ton, f.o.b. rail-shipping point.

Lithia mica total production in the state has been as follows:

Year	Tons	Value	Year	Tons	Value
1899	124	$4,600	1916	71	$1,065
1900	440	11,000	1917	880	8,800
1901	1,100	27,500	1918	4,111	73,998
1902	822	31,880	1919	800	14,400
1903	700	27,300	1920	10,046	153,502
1904	641	25,000	1921 } 1922 }	*1,365	20,781
1905	25	276			
1906					
1915	91	1,365	Totals	21,216	$401,467

*Annual details concealed under 'Unapportioned.'

MICA.

Bibliography: State Mineralogist Reports II, IV. Bulletins 38, 67, 91. U. S. Geol. Survy., Bull. 740; Min. Res. of U. S. Eng. & Min. Jour.-Press, Vol. 115, pp. 55-60, Jan. 13, 1923.

No commercial production of mica has recently been reported in California. Production in previous years has been as follows:

Year	Tons	Value
1902	50	$2,500
1903	50	3,800
1904	50	3,000
Totals	150	$9,300

The following summary of the uses and characteristics of mica is quoted from a recent article by Bowles:[1]

"Practically all marketable mica is of the muscovite or phlogopite types. Biotite and chlorite are sold in pulverized form, but the amount so used is so small that no further mention of them need be made. Mica falls generally into three classes: sheet mica, including punch; splittings, and scrap. Sheet mica is used chiefly for electrical purposes and for glazing; splittings are made into built-up mica; scrap is ground to a powder.

"Mica to be classified as sheet must yield a rectangle of at least 1½ x 2 in., must split evenly and freely, be free from cracks, rulings, or plications, and reasonably free from inclusions of foreign matter, though stains of a nonconducting character are permissible for some uses. Ability to withstand heat and high electrical resistance have led to a wide application of sheet mica in the electrical industries. The electrical uses of sheet mica greatly exceed all others in quantity and value of the material used. Mica has become so essential that some of the larger electrical companies own and operate their own mica mines, which supply only a part of their requirements. An important use of electrical mica is for inter-leaving between the copper segments of commutators. Its adaptability for such a purpose depends chiefly on its dielectric strength—that is, its ability to resist disruptive discharge due to difference in potential between the segments on either side of it. Only high-grade mica free from iron impurities, pin holes, or cracks may be so used. A soft variety of mica is preferable, in order that the copper and mica may wear down evenly, and in this respect it is claimed that Canadian amber mica is superior to all others.

"Specifications of Mica for Electrical Use.

"Thin films are used in vast numbers in condensers for magnetos and wireless apparatus. A high quality of mica is demanded for condenser use. It must be clear ruby, colorless or greenish, must split easily into smooth plates one-thousandth of an inch thick, and must be free from cracks, holes, stains, spots, wrinkles, rulings, air bubbles, or knots in any form. Large sizes are not usually required, 1½ x 2 or 2 x 3 in. being those ordinarily used. For wireless outfits each film must be capable of withstanding 20,000 volts. For magneto condensers a much lower electrical resistance is permissible.

[1]Bowles, Oliver, The marketing of mica: Eng. & Min. Jour.-Press, Vol. 115, pp. 55–60, Jan. 13, 1923.

"As sheets in greatly diversified shapes, or as washers and tubes, mica is used extensively as an insulator in dynamos and in various fittings or appliances, in fuse boxes, sockets, insulators, electric heaters, flatirons, and telephones. The highest grades of electrical mica are required for condensers and spark plugs, but for uses where low voltage currents are employed less perfect mica, containing a limited amount of impurities, may be employed.

"As a heat-resisting transparent medium, sheet mica has various uses. It is widely employed for stove windows, but this use has declined to a considerable extent. A hard and rigid mica that is nearly clear is best suited for stove fronts. Domestic mica, particularly mica from North Carolina, is well adapted for this use. Stove No. 1 must be free from cracks and stains, but may contain air bubbles. Stove No. 2 may be spotted and stained to a limited extent. High-grade stove mica commands a higher price than electrical mica, because for the most part larger sizes are demanded. Electrical companies that operate their own mines sell the larger sizes of clear sheet for glazing, and utilize the smaller sizes in electrical work. Mica is also used in furnace and bake-oven sight-holes, heat screens, lamp chimneys, canopies and shades, particularly for gas mantles, and also for military lanterns and in lantern slides. Micalite is a trade name given to sheet mica used in mica chimneys, canopies, and similar appliances. For lamp chimneys and canopies the mica must be clear and transparent, must split easily, and be very flexible. Indian and Brazilian mica are used chiefly for such purposes.

"Transparency of Mica a Valuable Characteristic.

"Its ability to withstand shocks and strains, combined with its transparency, has led to wide use in motor goggles, spectacles, diver's helmets, smoke helmets, compass cards, gage fronts, and in windows subject to shock, as in the conning towers of warships.

"Owing to the resonance of mica, circular sheets of high-grade muscovite are used extensively in phonographs, as sound-producing devices. Such sheets are used also in other sound-detecting instruments, such as submarine detectors. Diaphragm mica must be clear and transparent, free from all cracks, inclusions, stains, air bubbles, or rulings, and must split easily into perfectly flat sheets, the latter feature being essential.

"Mica splittings consist of thin flakes split from the smaller sheets or from waste fragments. They are usually not less than one square inch in area, of irregular shape and not more than one-thousandth of an inch in thickness. They are used for the manufacture of built-up mica, consisting of the thin plates stuck together with shellac. Built-up mica is used chiefly for commutator segments, and in various forms in dynamos, motors, and transformers.

"The invention of built-up mica marks one of the most important developments in the industry. Many hundred tons of splittings are used every year in making products that are quite satisfactory for many electrical purposes, thus filling a demand which it would be impossible for the world to supply with sheet mica at the present rate of production.

"Mica trimmings and blocks that can not be utilized for sheet mica or splittings are ground and sold in pulverized form. The more impure and coarser types are used as a coating on tar roofing to prevent sticking when rolled. Purer and finer-grained products are used in paints, ornamental tiles, and concrete. A mixture of ground mica and powdered aluminum is said to make a rust-preventing paint of good quality.

"On account of its heat-resisting qualities, ground mica is used in railroad car axle packings, in pipe and boiler coverings, in fireproof paints, and in rubber tires. Ground mica is used in annealing steel, as an absorbent for nitroglycerin in the manufacture of certain explosives, as a component in roofing, as a filler in rubber and other products, in calico printing, and as tire powder. It is used also in tinsel decorations and as 'Santa Claus snow' for Christmas tree and window decorations. The purest and finest ground mica is used for wall-paper decoration, as a lubricant for wooden bearings, and mixed with oil as a lubricant for metal bearings.

"Table I indicates the approximate proportion of ground mica used for various purposes.

"Table I—Percentages of Ground Mica Used in Various Applications.

Patent roofing	60
Wall paper	21
Automobile tires	8
Fancy paints, concrete facing, Christmas tree 'snow'	3
Molded electric insulation	3
Annealing, filling in rubber other than tires, printing, lithography and sizing cotton	3
Lubrication	2

"From the preceding paragraphs it appears that the chief industries using sheet mica and splittings are manufacturers of electrical equipment, stoves, phonographs, lamp shades, and chimneys. Ground mica is used by manufacturers of composition roofing, rubber products, wall paper, and lubricants.

"The chief centers of mica consumption are the large industrial cities east of the Mississippi River, such as Chicago, New York, Schenectady, Cleveland, Pittsburgh, and Boston. The chief domestic marketing points are Asheville and Spruce Pine, N. C.; Keene, N. H.; New York City, Boston, and Chicago. The chief foreign mica markets are London, England; Calcutta, India; Rio Janeiro, Brazil; Buenos Aires, Argentina, and Cape Town, South Africa."

MINERAL PAINT.

Bibliography: State Mineralogist Reports XII-XVIII (inc.). Bulletins 38, 91.

Mineral paint materials were produced in California in 1922 from a total of eight properties in the following four counties: Nevada, Placer, Stanislaus, and Ventura. The total amounted to 1620 tons, valued at $13,277, being an increase over the 446 tons and $4,748 of 1921. The material shipped from Nevada and Placer counties is hematite; from Stanislaus, yellow ochre; and that from Ventura, red ochre.

Besides the above-named counties, deposits of mineral paint have been noted, and in the past most of them have yielded some commercially, in the following: Alameda, Amador, Calaveras, Colusa, Imperial, Kern, Kings, Lake, Los Angeles, Riverside, Santa Cruz, Sonoma.

Mineral Paint Production of California, by Years.

The first recorded production of mineral paint materials in the state was in the year 1890. The output, showing annual amount and value, since that time, is given herewith:

Year	Tons	Value	Year	Tons	Value
1890	40	$480	1908	335	$2,250
1891	22	880	1909	305	2,325
1892	25	750	1910	200	2,040
1893	590	26,795	1911	186	1,184
1894	610	14,140	1912	300	1,800
1895	750	8,425	1913	303	1,780
1896	395	5,540	1914	132	847
1897	578	8,165	1915	311	1,756
1898	653	9,698	1916	643	3,960
1899	1,704	20,294	1917	520	2,700
1900	529	3,993	1918	728	4,738
1901	325	875	1919	1,780	17,055
1902	589	1,533	1920	779	8,477
1903	2,370	3,720	1921	446	4,748
1904	270	1,985	1922	1,620	13,277
1905	754	4,025			
1906	250	1,720	Totals	18,692	$176,675
1907	250	1,720			

MINERAL WATER.

Bibliography: State Mineralogist Reports VI, XII-XVIII (inc.). U. S. G. S., Water Supply Paper 338; Min. Res. 1914, 1916. 'Mineral Springs and Health Resorts of California,' by Dr. Winslow Anderson, 1890. U. S. Dept. of Agr., Bur. of Chem., Bulletin 91.

A widespread production of mineral water is shown annually in California. These figures refer to mineral water actually bottled for sale, or for local consumption. Water from some of the springs having a special medicinal value brings a price many times higher than the average shown, while in some cases the water is used merely for drink-

ing purposes and sells for a nominal figure. Health and pleasure resorts are located at many of the springs. The waters of some of the hot springs are not suitable for drinking, but are very efficacious for bathing.

From a therapeutic standpoint, California is particularly rich in mineral springs. The counterparts of many of the world-famed spas of Europe and the eastern United States can be found here. In discussing the curtailment of foreign imports into the United States during the European war period, Chambers[1] comparing some American and European mineral waters says:

"Those who have found it difficult or impossible to obtain waters that were previously imported will doubtless be interested in the possibility of substituting domestic waters for certain famous mineral waters of Europe. * * * To discover two or more natural waters each of whose dozen or more constituents is exactly the same in kind and concentration would be difficult if not impossible, but an attempt is made here to show that the waters compared are similar in chemical character, degree of mineralization, and relative proportion of various constituents. As medical practice varies sometimes as much as 100 per cent in the dosage of many of the inorganic substances present in natural solutions, it seems reasonable to assume that waters differing not too widely in composition might be used for the same purpose with similar if not identical physiologic effects.

"The American waters chosen for this study have been those for which the analyses were at hand. A more exhaustive study would no doubt reveal many others of equal value for comparison.

"Many more comparisons could be made. Hinsdale[2] gives a list that includes about about 40 European waters and that indicates for each 1 to 7 similar American waters. As a large part of the cost of imported waters is chargeable to freight and handling, it would seem unnecessary to pay high prices for imported waters if equally satisfactory and less expensive waters can be obtained in this country.

"When American springs are more fully investigated and exploited, and when better accommodations for hydrotherapeutic treatment are available, it may be hoped that in the United States counterparts of nearly all the famous spring resorts in Europe will be developed. There is also a satisfaction in the assurance that if mineral waters are a war-time necessity in convalescent hospitals, supplies from abroad may be completely shut off without deprivation to patients in this country."

In the analyses chosen, Chambers[3] compares two of California's springs with springs at Aix-les-Bains, France, and at Carlsbad, Austria-Hungary, respectively.

An interesting development in recent years in California is the obtaining of 'geyser' wells at Calistoga, in Napa County, by drilling into the thermal-water strata underlying that part of the Napa Valley. There are at present several wells so erupting. They spout in true geyser fashion, and their periods vary from 10 minutes to 2 hours, each following its own schedule rather closely. Radioactivity has been noted in at least two localities in California. Some preliminary qualitative tests have been made by the writer at The Geysers in Sonoma County, and positive reactions obtained; also, radioactivity has been proved at Arrowhead Hot Springs in San Bernardino County, by Prof. Gilbert E. Bailey of the University of Southern California.

[1]Chambers, A. A., Comparison of American and European mineral waters: U. S. Geol. Surv., Min. Res. of U. S., 1916, Part II, pp. 500–510, 1918.
[2]Hinsdale, Guy. Some analogous European and American mineral springs: Am. Climatological Assoc. Trans., vol. 17, pp. 263–265, 1901.
[3]Idem, pp. 506, 507, 508.

Commercial production of mineral water by counties, in 1922, was as follows:

County	Gallons	Value
Butte	2,835	$2,485
Calaveras	1,914	639
Lake	60,420	29,370
Los Angeles	300,400	15,450
Napa	80,481	54,341
Riverside	58,115	16,672
San Diego	71,781	9,262
Santa Barbara	110,552	52,269
Santa Clara	3,500	325
Sonoma	35,843	9,108
Colusa, Contra Costa, Humboldt, Marin, Placer, San Bernardino, San Benito, San Luis Obispo, Siskiyou, and Solano*	3,550,505	296,503
Totals	4,276,346	$486,424

*Combined to conceal output of a single operator in each.

The production above tabulated was in part bottled with artificial carbonation, in part natural, and a large part was used in the preparation of soft drinks with flavors.

Mineral Water Production of California, by Years.

Amount and value of mineral water produced in California since 1887 are given herewith:

Year	Gallons	Value	Year	Gallons	Value
1887	618,162	$144,368	1906	1,585,690	$478,186
1888	1,112,202	252,990	1907	2,924,269	544,016
1889	808,625	252,241	1908	2,789,715	560,507
1890	258,722	89,786	1909	2,449,834	465,488
1891	334,553	139,959	1910	2,335,259	522,009
1892	331,875	162,019	1911	2,637,669	590,654
1893	383,179	90,667	1912	2,497,794	529,384
1894	402,275	184,481	1913	2,350,792	599,748
1895	701,397	291,500	1914	2,443,572	476,169
1896	808,843	337,434	1915	2,274,267	467,738
1897	1,508,192	345,863	1916	2,273,817	410,112
1898	1,429,809	213,817	1917	1,942.020	340,566
1899	1,338,537	406,691	1918	1,808,791	375,650
1900	2,456,115	268,607	1919	2,233,842	340,117
1901	1,555,328	559,057	1920	2,391,791	421,643
1902	1,701,142	612,477	1921	3,446,278	367,476
1903	2,056,340	558,201	1922	4,276,346	486,424
1904	2,430,320	496,946			
1905	2,194,150	538,700	Totals	65,091,512	$13,921,691

PHOSPHATES.

Bibliography: Bulletins 67, 91.

No commercial production of phosphates has been recorded from California, though occasional pockets of the lithia phosphate, amblygonite, Li (AlF) PO_4, have been found associated with the gem tourmaline deposits in San Diego County. Such production has been classified under lithia.

A deposit of phosphate rock is reported to have been located near Big Pine in Inyo County, but no commercial development has taken place.

PUMICE and VOLCANIC ASH.

Bibliography: State Mineralogist Reports XII, XIV, XV, XVII, XVIII. Bulletin 38 (see 'Tufa').

The production of pumice and volcanic ash for the year 1922 amounted to 613 tons valued at $4,248, and came from a single property, each, in Imperial, Inyo, and San Francisco counties. This is an increase in tonnage but a decrease in total value from the 1921 yield.

The pumice deposits in Imperial and Siskiyou counties are of the vesicular, block variety, and are practically the only localities in the United States from which commercial production of this grade has been made. There are other known deposits of this variety in Inyo, Madera, and Mono counties. This form is used largely for abrasive purposes; and is also being utilized in fire-brick, and as an insulating filler in the walls of refrigerators and cold-storage plants. It has also been tried in concrete construction. Foreign importations of block pumice come mainly from the Lipari Islands, Italy. The volcanic ash, or tuff, variety is employed in making scouring soaps and polishing powders. The above-noted production from Inyo and San Francisco counties was of ash.

Commercial production of pumice in California was first reported to the State Mining Bureau in 1909, then not again until 1912, since which year there has been a small annual output, as indicated by the following table:

Year	Tons	Value	Year	Tons	Value
1909	50	$500	1917	525	$5,295
1910			1918	2,114	28,669
1911			1919	2,388	43,657
1912	100	2,500	1920	1,537	25,890
1913	3,590	4,500	1921	406	6,310
1914	50	1,000	1922	613	4,248
1915	380	6,400			
1916	1,246	18,092	Totals	12,999	$147,061

PYRITES.

Bibliography: Report XVIII. Bulletins 38, 91. Min. & Sci. Press, Vol. 114, pp. 825, 840.

Pyrites are mined for use in the manufacture of sulphuric acid, which in turn is used in large quantities in the preparation of explosives and of fertilizers. One property, each, in Alameda, Shasta, and Mariposa counties reported a total production in 1922 of 151,381 tons, valued at $570,425, which is an increase over 1921, both in tonnage and value. The material shipped in 1922 carried 42% to 46% S.

This does not include the large quantities of pyrite, chalcopyrite and other sulphides which are otherwise treated for their valuable metal contents. Some sulphuric acid is annually made as a by-product in

the course of roasting certain tonnages of Mother Lode auriferous concentrates for their precious-metal values. California has available supplies of sulphide ores suitable for the manufacture of sulphuric acid far in excess of the local requirements.

Pyrites Production in California, by Years.

The total recorded pyrites production in California to date is as follows:

Year	Tons	Value	Year	Tons	Value
1898	6,000	$30,000	1911	54,225	$182,954
1899	5,400	28,620	1912	69,872	203,470
1900	3,642	21,133	1913	79,000	218,537
1901	4,578	18,429	1914	79,267	230,058
1902	17,525	60,306	1915	92,462	293,148
1903	24,311	94,000	1916	120,525	372,969
1904	15,043	62,992	1917	111,325	323,704
1905	15,503	63,958	1918	128,329	425,012
1906	46,689	145,895	1919	147,024	540,300
1907	82,270	251,774	1920	146,001	530,581
1908	107,081	610,335	1921	110,025	473,735
1909	457,867	1,389,802	1922	151,381	570,425
1910	42,621	179,862			
			Totals	2,117,966	$7,322,049

SHALE OIL.

Bibliography: State Mineralogist Report XIX. U. S. Geol. Surv., Bulletins 322, 729. U. S. Bur. of Mines, Bull. 210.

The commercial production of shale oil was begun in California in 1922 by a plant near Casmalia, in Santa Barbara County. Their product was sold for utilization as a flotation oil in metallurgical work. The property and plant are described by Gore[1] in a recent issue of 'Mining in California.' As there was only a single operator the amount and value of the output are concealed under the 'unapportioned' item.

SILICA (Sand and Quartz).

Bibliography: State Mineralogist Reports IX, XIV, XV, XVII, XVIII. Bulletins 38, 67, 91.

We combine these materials because of the overlapping roles of vein quartz which is mined for use in glass making and as an abrasive, and that of silica sand which, although mainly utilized in glass manufacture, also serves as an abrasive. Both varieties are also utilized to some extent in fire-brick manufacture.

A portion of the tonnage of vein quartz in California in 1916 and 1917 was employed in the preparation of ferro-silicon by the electric furnace. At present, some is utilized as a foundry flux, and for steel-

[1]Gore. F. D., Oil shale in Santa Barbara County, California: State Min. Bur., Report XIX, Sept. 1923.

casting moulds. A portion of the silica sold (both sand and quartz) is also used in glazes for porcelain, pottery and tile, and in the body of the ware to diminish shrinkage; and some of the sand for the preparation of sodium silicate ('water glass'). Manufacturers of paint use finely ground silica, which forms as much as one-third of the total pigment in some paints. For certain purposes finely ground crystalline material is superior in paints to other materials because of the angularity of the grains, which makes them adhere more firmly to the article painted and after wear afford a good surface for repainting. The same angularity makes artificially comminuted crystalline quartz superior to natural sand for use in wood fillers. It is also preferable for soaps and polishing powders.

We do not include under this heading such forms of silica as: quartzite, sandstone, flint, tripoli, diatomaceous earth, nor the gem forms of 'rock crystal,' amethyst, and opal. Each of these has various industrial uses, which are treated under their own designations.

The production of silica in California in 1922 amounted to 9,874 tons, valued at $31,016, from eleven properties in six counties, distributed as follows:

County	Tons	Value
Amador	865	$5,030
Placer	2,000	5,500
Riverside	1,877	11,391
Kern, Monterey, San Diego*	5,132	9,095
Totals	9,874	$31,016

*Combined to conceal output of a single operator in each.

Of the above total, 5,811 tons was of sand, and 4,063 tons of vein and boulder quartz. For making the higher grades of glass, most of the sand is imported from Belgium. There are various deposits of quartz in California which could be utilized for glass making, but to date they have not been so used owing to the cost of grinding and the difficulty of preventing contamination by iron while grinding.

Silica sand has been produced in the following counties of the state: Alameda, Amador, El Dorado, Los Angeles, Monterey, Orange, Placer, Riverside, San Joaquin, and Tulare. The chief producing centers have been Amador, Monterey, and Los Angeles counties. The industry is of limited importance, so far, because of the fact that much of the available material is not of a grade which will produce first-class colorless glass; for such, it must be essentially iron-free. Even a fractional per cent of iron imparts a green color to the glass.

Belgium sand is also displacing local material in the manufacture of sodium silicate ('water glass'), causing the closing down of operations in January of the present year, of the sand plant of the Philadelphia Quartz Company in Amador County.

Total Silica Production of California.

Total silica production in California since the inception of the industry, in 1899, is shown below, being mainly sand:

Year	Tons	Value	Year	Tons	Value
1899	3,000	$3,500	1912	13,075	$15,404
1900	2,200	2,200	1913	18,618	21,899
1901	5,000	16,250	1914	28,538	22,688
1902	4,500	12,225	1915	28,904	34,322
1903	7,725	7,525	1916	20,880	48,908
1904	10,004	12,276	1917	19,376	41,166
1905	9,257	8,121	1918	23,257	88,930
1906	9,750	13,375	1919	18,659	101,600
1907	11,065	8,178	1920	25,324	96,793
1908	9,255	22,045	1921	10,569	49,179
1909	12,259	25,517	1922	9,874	31,016
1910	19,224	18,265			
1911	8,620	8,672	Totals	328,933	$710,054

SILLIMANITE.

Bibliography: Bulletins 67, 91. Dana's Mineralogy.

Sillimanite is an aluminum silicate (Al_2SiO_5), having the same composition and formula as andalusite, but having different physical characteristics. Theoretically, they both contain 63.2% Al_2O_3 and 36.8% SiO_2. Both are found in gneiss, mica schist, and other related crystalline metamorphic rocks.

A massive deposit of sillimanite found in Dry Creek Canyon in the Inyo Mountains, Mono County, is being mined, and the material shipped East, where it is utilized in the manufacture of porcelain for automobile spark plugs, and for high-tension electrical insulators. This is apparently the only deposit of sillimanite thus far found in the United States (at least) in sufficient quantity to be of commercial consequence. As there was only the one operator, the tonnage and value of the 1922 production is concealed under the 'unapportioned' item.

SOAPSTONE and TALC.

Bibliography: State Mineralogist Reports XII, XIV, XV, XVII, XVIII. Bulletins 38, 67, 91. U. S. Bur. of Mines, Bulletin 213. Rep. of Investigations, Serial No. 2253, May, 1921.

The total output of talc and soapstone in California in 1922 amounted to 13,378 tons valued at $197,186, from two producers, each, in El Dorado and Inyo counties, and one in San Bernardino. This is an increase both in tonnage and value over the 1922 figures. The bulk of the product was high-grade talc from Inyo and San Bernardino counties. This was due, in part to improvement in the eastern demand for California talc on account of its high quality, in part to a 10% reduction in freight rates in July, 1922, and in part to the increases in tariff duties placed on foreign importations of talc by the Tariff Act of 1922 which became effective in September. It is reported that California talc is steadily replacing imported talc in the toilet trade on the basis

of quality. The largest production of talc in the United States comes from Vermont and New York, and of massive soapstone from Virginia.

Composition and Varieties.

Talc is a hydrous magnesium silicate with the chemical formula $H_2Mg_3(SiO_3)_4$. It is also called soapstone, and steatite. The term 'talc' properly includes all forms of the pure mineral, whereas 'steatite' denotes particularly the massive, compact variety, and 'soapstone' the impure, massive forms containing as low as 50% of talc. When pure, talc is soft, having a hardness of 1, but impurities increase the hardness up to 3 or 4. The color varies from pure white and silvery white through gray, green, apple green, to dark green, also yellow, brown, and reddish when impure. It is commonly compact or massive, or in fine granular aggregates, and often in foliated plates or in fibrous aggregates.

Uses.

Although the uses of talc and soapstone are many and varied, some of them are not in general well known nor fully developed; and although few of their uses can justly be considered essential in the sense that no substitutes can be used, there are several which are of great importance. The widest use of talc is in the powdered form, and the value depends upon color (whiteness), uniformity, fineness of grain, freedom from grit, 'slip,' and sometimes freedom from lime. The white varieties, free from grit and iron, low in lime, ground to 200-mesh and finer, are largely used as a filler for paper, rubber and paint, and the very highest grade as toilet powder. Ground talc is also used in dressing and coating cloth, in making soap, rope, twine, pipe-covering compounds, heavy lubricants, and polishes. Ground talc and soapstone are used for foundry facings, either alone or mixed with graphite; and a coarser grade is used in the manufacture of asphalt-coated roofing felts and papers, both as a filler and as a surfacing. Massive, close-grained talc, free from iron and grit, is cut into blanks and baked, forming the material used for gas tips and electrical insulation, commercially known as 'lava.' Its hardness, its resistance to heat, acids, and alkalies, and its great dielectric strength make it very useful for electric insulation, and no satisfactory substitute for it has been found.

Massive varieties of talc, pyrophyllite, and high grades of soapstone are cut into slate pencils, and steel-workers' crayons. 'French chalk' or 'tailor's chalk' is a soft, massive talc. In China, Japan, and India, massive talc (steatite) is carved into grotesque images and other forms, and is often sold as imitation jade. Soapstone is usually cut into slabs of 1 to 2 inches in thickness and sold as griddles, footwarmers, and fireless-cooker stones, or fabricated into laundry sinks and tubs, laboratory-table tops, hoods, tanks, and sinks, electric switchboards, and for other uses in which the properties of resistance to heat, acids, and alkalies, and electricity are essential.

The following detailed account of the various uses of talc and soapstone is given by Ladoo[1]:

[1]Ladoo, R. B., Talc and soapstone, their mining, milling, products, and uses: U. S. Bur. of Mines, Bulletin 213, pp. 66–70, 1923.

"**Uses of Powdered Talc and Soapstone.**

"1. Paper manufacture:
a. Filling or loading of all grades of paper.
b. Ingredient of coating mixture on glazed or finished papers.
c. In tissue-paper manufacture from sulphite stock.
d. In the manufacture of blotting and absorbing papers.
e. For the bleaching of cellulose.
f. For removal of resin from cellulose.
Quality: 200-mesh or finer. Colloidal property demanded. Presence of lime sometimes objectionable.
Color: Colorless; free from ferric salts, for white paper. Color not important for wrapping paper.*

"2. Roofing-paper manufacture:
a. Filling or loading.
b. Coating, to prevent sticking together.
c. Surfacing.
Quality: For filling and coating, 200-mesh. For surfacing, 40 to 80 mesh.
Color: Negligible.

"3. Textile manufacture:
a. Dressing cloth.
b. Coating, sizing, and bleaching cotton cloth.
c. Dyeing.
d. Dry polishing or sizing of pile fabrics.
Quality: 200-mesh.
Color: Dependent on use.

"4. Rubber manufacture:
a. Filling.
b. Dusting.
c. Packing material for rubber.
d. Protective coating for crude rubber.
e. On molding tables in making tires.
f. In manufacture of rubber tubing for bedding tubing during vulcanization.
Quality: 200-mesh.
Color: Negligible.

"5. Paint manufacture:
a. Pigments; absorption of complex coloring matters.
b. Filler or extender, particularly in mixed paints.
c. Cold-water paints.
d. Enamel paints.
e. Waterproof paints for protection of metal, stone, and wood.
f. Flexible roofing paints and cements.
g. Fireproof or fire-resistant paints.
h. Base for disinfectant paints.
Quality: 200-mesh or finer. Colloidal property demanded in most paints.
Color: Dependent on use.

"6. Soap manufacture:
a. Filler.
b. Constituent of soap compound.
Quality: 200-mesh only, colloidal property demanded in *b.*
Color: Dependent on use.

"7. Foundry-facing manufacture:
a. Replacing graphite.
b. Mixed with graphite.
Quality: 200-mesh.
Color: Dependent on use.

"8. Toilet preparations:
a. Face powders.
b. Toilet powders.
c. Foot powders.
d. Creams, pastes, and lotions.
Quality: 200-mesh or finer; freedom from grit, iron, and lime; good slip. Colloidal property advantageous when used with liquids.
Color: White or flesh color.

"9. Wire insulating compounds:
Quality: 200-mesh.
Color: Dependent on use.

"10. Lubricants, liquid or grease:
a. Talc alone.
b. Incorporated with heavy oils, 40 to 60 per cent talc.
c. With water, talc in colloidal state.
Quality: 200-mesh.
Color: Negligible.

"11. Linoleum and oilcloth manufacture:
a. Filling.
b. Dusting.
Quality: 200-mesh.
Color: Dependent on use.

"12 Pipe-covering compounds.

"13. Pottery and porcelain:
a. Body material for china, porcelain, and porcelain crucibles.
b. Glaze.

"14. Electrical insulation:
a. Artificial or synthetic lava—talc with binder.
b. Substitute for electrical porcelain—talc with clay, with or without liquid binder.
Quality: 200-mesh.
Color: Dependent on use.

"15. Rope and twine manufacture:
  a. Filling.
  b. Finishing.
  Quality: 200-mesh.
  Color: Dependent on use.
"16. Leather manufacture:
  a. Dressing skins and leathers.
  b. Drying oily leathers.
  c. Substitute for wheat flour in making glacé kid
"17. Cork manufacture:
  a. Dusting molds.
  Quality: 200-mesh.
  Color: Negligible.
"18. Oil manufacture:
  a. Filtering medium.
  Quality: 200-mesh.
  Color: Negligible.
"19. Glass industry:
  a. Polishing powder for glass, especially plate glass.
  b. Dimming and clouding glass.
  c. Dusting glass, bottle molds.
  Quality: 200-mesh.
  Color: Negligible.
"20. Portland cement and concrete:
  a. Ingredient of special cements.
  b. Part of concrete aggregate.
  c. Surfacing material.
"21. Wall plaster:
  a. Ingredient.
  b. Finishing.
"22. Asbestos industry:
  Ingredient of asbestos shingles, blocks, and slabs.
"23. Manufacture of crayons, plaques, and blocks.
"24. Preservative coating on stonework.
"25. Cleaning and polishing rice, peas, coffee, beans, maize, barley, peanuts, and similar food stuffs:
  Quality: 200-mesh.
  Color: Negligible; colored talcs are used for colored products.
"26. Bleaching barley grain of inferior color. Used with sulphur-dioxide gas:
  Quality: 200-mesh.
  Color: Negligible.
"27. Dusting in rubber-stamp manufacture:
  Quality: 200-mesh.
  Color: Negligible.
"28. Composition floor manufactures.
"29. Insulating material for switchboards and floors of generating stations.
"30. Imitation stone:
  a. Marble and jointless flooring.
  b. Sanitary appliances.
"31. Boot and shoe powder:
  Quality: 200-mesh.
"32. Glove powder:
  Quality: 200-mesh.
  Color: White.
"33. Dermatology:
  a. Absorbing colors, colloidal solutions, fats, and oils.
  b. Absorbing odors.
"34. Absorbing colors of animal, plant, and artificial origin.
"35. Veterinary surgery:
  For dusting wounds and sores, and for treating skin diseases of cattle and other animals.
"36. Purifying, decolorizing, and degreasing of waste waters:
  Quality: 200-mesh. Colloidal properties demanded.
  Color: Negligible.
"37. Manufacture of water filters, similar to Berkfeld.
"38. Conserving fruits, vegetables, and eggs.
"39. Sugar refining.
"40. Contact material for catalytic reactions.
"41. Absorbent for nitroglycerin.
"42. Packing material for metallic sodium and potassium:
  Used wetted with oil.
"43. Fireproofing wood:
  Used with sodium silicate (water glass).
"44. Acid-proof and fireproof packing and cement, for pipe, and such articles.
"45. Automobile polish.
"46. Filler in manufacture of fertilizers.
"47. Agriculture:
  a. Filler or extender for insecticides.
  b. Ingredient of remedies for plant diseases, such as 'Fostit' or mixture of copper sulphate with ground talc or soapstone.
"48. Shoe polish and cleaner:
  a. Cleaner for white canvas and buckskin shoes.
  b. Ingredient of polish for leather shoes.
"49. Yarn and thread manufacture:
  a. Dressing.
  b. Polish.

"50. Chemical-pharmaceutical industry:
   a. Powder.
   b. Tablets.
"51. Colored crayons:
   a. Crayons of chrome colors, and pastel colors.
"52. Stove polishes.
"53. Imitation amber:
   For clouding effects.
"54. Cleaning and glossing of hair and bristles.
"55. Floor wax.
"56. Terrazzo or mosaic flooring:
   In place of oil in laying terrazzo.
"57. Candy manufacture:
   With starch, or other medium as dusting agent to prevent sticking in molds, on molding boards, etc.
"58. Window shade manufacture; to render cloth opaque.
"59. Chewing-gum manufacture; as dusting agent to prevent sticking.
"60. In manufacture of putty, as filler.

"Uses of Massive Talc and Soapstone.

"1. Lava blanks for electrical insulation, gas burner tips, and spark plugs:
   Quality: Massive, fine-grained talc, free from iron and grit, no cracks or cleavage planes. Must be soft and easily machineable but compact and strong. Must be tested under heat.
   Color: Negligible in raw state, but white color preferable after burning.
"2. Crayons and pencils:
   Quality: Compact, massive talc, medium hard, strong when sawed into thin, narrow strips.
   Color: Negligible.
"3. Tailors chalk or French chalk.
   Quality: Compact and strong, fine grained, but medium soft.
   Color: White or light color.
"4. Glass making:
   Molds for bottles, watch glasses, etc.
"5. Metallurgical industries:
   Molds for casting of iron, brass, copper, etc.
"6. Refractories:
   Fire brick and blocks.
"7. Polishing agent:
   a. Wooden handles, etc. Small blocks of talc tumbled in cylinder with wooden handles to fill grain of wood and give rough polish.
   b. Polishing and lubricating wire nails used in automatic box-nailing machines. Blocks of talc tumbled with nails.
"8. Carvings:
   Chinese and other Oriental carvings.
"9. Cooking utensils:
   Used by uncivilized people in various parts of the world.
"10. Soapstone slabs:
   a. Electrical switchboards and base plates.
   b. Acid-proof laboratory tables, sinks, hoods, and tanks.
   c. Laundry tubs and sinks.
   d. Fireless-cooker stones.
   e. Foot warmers.
   f. Griddles."

Foreign and Domestic Talcs.

Foreign importations of high-grade white talc suitable for the manufacture of toilet powder have come mainly from Canada, Italy and France. A small, irregular production of white talc was obtained from certain eastern states, but the material fluctuated in quality and quantity to such an extent that it was not largely used by manufacturers of the better-grade toilet powders. Gradually a wall of prejudice against all domestic talcs grew up in the trade, and this has been fostered by people interested in the sale of the imported article.

Deposits of high-grade talc in California have been known for several years, but little interest was shown in them until 1911–1912. The lack of importations during 1917–1919, gave California an opportunity to demonstrate the quality of her goods. According to Ladoo[2]:

"In the essential qualities of pure white color, freedom from grit, and fine-grain size it is a well-established fact that the best California talcs equal or surpass the best imported talcs. In the debatable qualities of slip and freedom from lime some of the best California talcs equal some of the best imported talcs and in other cases excel

[2]Ladoo, R. B., High-grade talc and the California talc industry: U. S. Bur. of M., Reports of Investigations, Serial No. 2253, May, 1921.

other imported talcs. Some of the very largest consumers of toilet-grade talc have expressed complete satisfaction with the high-grade California talcs and have used them regularly in preference to Italian talc.

"Therefore, it can not be truthfully said that the United States produces no talcs equal in quality to imported talcs. Unfortunately many domestic consumers have been so thoroughly imbued with the alleged superiority of imported talcs that domestic talcs have not been given a fair chance. It is even reported that unscrupulous dealers have relabeled domestic talc and sold it as Italian talc, with prefect satisfaction to the consumers. Such dishonest trade practices are probably not common, but they serve to refute the erroneous statements regarding the quality of domestic talc."

Foreign producers have the benefit of cheap labor, and a low tariff import duty. In addition to these disadvantages, the California operators are up against high transcontinental freight rates. In 1921 imports amounted to 18,264 short tons of ground talc, valued at $371,329.

It is stated that in Italy the mines are all small tunnel workings, operated in the main by people of limited capital. Few of the companies have their own mills, the mills being separate enterprises, located at a central point, to which all the lump talc is hauled by teams. Practically all of these mines are in the northwestern corner of Italy, in the district of Pinerolo (Val Chisone), near Turin (Torino), in the province of Piedmont.

Talc Production of California, by Years.

Production has been intermittent in the state since 1893, as shown in the following table:

Year	Tons	Value	Year	Tons	Value
1893	400	$17,750	1909	33	$280
1894			1910	740	7,260
1895	25	375	1911		
1896			1912	1,750	7,350
1897			1913	1,350	6,150
1898			1914	1,000	4,500
1899			1915	1,663	14,750
1900			1916	1,703	9,831
1901	10	119	1917	5,267	45,279
1902	14	288	1918	11,760	85,534
1903	219	10,124	1919	8,764	115,091
1904	228	2,315	1920	11,327	221,362
1905	300	3,000	1921	8,752	130,078
1906			1922	13,378	197,186
1907					
1908	3	48	Totals	68,686	$878,670

STRONTIUM.

Bibliography: Bulletins 67, 91. U. S. G. S., Bull. 540; 660–I.

There has been no production of strontium minerals in California since 1918, though in that year both celestite ($SrSO_4$), and the carbonate, strontianite ($SrCO_3$) were shipped. The first recorded commercial output of strontium minerals in California was in 1916. The occurrence of the carbonate is particularly interesting and valuable, as it appears to be the first considerable deposit of commercial importance so far opened up in the United States. Shipments reported as averaging 80% $SrCO_3$ have been made. The deposit is associated with deposits of barite, near Barstow, San Bernardino County. The carbonate has also been found in massive form near Shoshone, Inyo County. In addi-

tion to Imperial County, celestite is found near Calico and Ludlow, and in the Avawatz Mountains in San Bernardino County, but as yet undeveloped.

Production of strontium minerals in California, by years, has been as follows:

Year	Tons	Value
1916	57	$2,850
1917	3,050	37,000
1918	2,900	33,000
1919		
Totals	6,007	$72,850

The principal use for strontium in the United States is in the form of the nitrate in the manufacture of red flares, or Costen and Bengal lights and fireworks. Previous to 1914, the nitrate was imported from Germany, England, and Sicily. In Germany and Russia, strontium in the form of the hydroxide is used in the manufacture of beet sugar. It is stated that strontia is more efficient and satisfactory in that process than lime, as it gives an additional recovery of 6% to 8%.

Of the two minerals, strontianite (carbonate) and celestite (sulphate), the carbonate is the more desirable as it is easier to convert to other salts; but it is scarcer. Celestite is found with limestone and sandstone and is sometimes associated with gypsum. Strontianite is also found with limestone, but associated with barite and calcite.

SULPHUR.

Bibliography: State Mineralogist Reports IV, XIII, XIV. Bulletins 38, 67, 91.

There has not been, for many years, any commercial output of native sulphur in California, although this mineral has been found to some extent in Colusa, Imperial, Inyo, Kern, Lake, Mariposa, San Bernardino, Shasta, Sonoma, Tehama, and Ventura counties.

Sulphur was produced at the famous Sulphur Bank mine in Lake County, during the years 1865–1868 (inc.), totaling 941 tons, valued at $53,500; following which the property became more valuable for its quicksilver. The Elgin mine, near Wilbur Springs, Colusa County, is a similar occurrence. There are prospects for some production for 1923, as two plants have begun operations in western Kern County.

The principal sources in the United States are the stratified deposits in Louisiana and Texas, extraction being accomplished by a unique system of wells with steam pipes. It is stated that the three large companies operating there are capable of producing more than 1,000,000 tons annually in excess of our normal consumption in the United States, which averages about 600,000 tons. The mines at Freeport, Texas, are in a peculiarly favorable location in that they are practically at tidewater.

Formerly considerable sulphur was imported from Italy and from Japan; but the situation is now reversed, so that in 1922, a total of 485,706 long tons valued at $7,095,964 was exported from the United States, principally to Europe and Canada.

CHAPTER SIX.

SALINES.

Bibliography: State Mineralogist Reports XIV, XV, XVII. Bulletin 24.

Under this heading are included borax, common salt, soda, potash, and other alkaline salts. The first two have been produced in a number of localities in California, more or less regularly since the early sixties. Except for a single year's absence, soda has had a continuous production since 1894. Potash, magnesium chloride and sulphate, and calcium chloride have only recently been added to the commercial list, while the nitrates are still prospective.

Our main resources of salines are the lake beds of the desert regions of Imperial, Inyo, Kern, Los Angeles, San Bernardino, San Luis Obispo, and Siskiyou counties, and the waters of the Pacific Ocean.

Substance	1921		1922		Increase+ Decrease— Value
	Tons	Value	Tons	Value	
Borates	50,136	$1,096,326	[a]39,087	$1,068,025	$28,301—
Calcium chloride	683	22,980	*	*	* —
Magnesium salts	4,153	106,140	3,036	89,788	16,352—
Potash	14,806	390,210	17,776	584,388	194,178+
Salt	197,989	832,702	223,238	819,187	13,515—
Soda	14,828	438,996	20,084	573,661	134,665+
Total values		$2,887,354		$3,135,049	
Net increase					$247,695+

*Concealed under 'Unapportioned.' [a]Recalculated to 40% 'anhydrous boric acid' equivalent.

BORATES.

Bibliography: State Mineralogist Reports III, X, XII, XIII, XIV, XV, XVII, XVIII. Bulletins 24, 67, 91.

During 1922, there was produced in California, a total of 74,998 tons of borate materials, compared with a total of 50,136 tons for the year 1921. The material shipped in 1922 included crude and selected colemanite ore varying from 12.54% to 32.16% anhydrous boric acid ("A. B. A."), also refined borax recovered from evaporation of brines at Searles Lake in San Bernardino County (See also under Potash).

As the crude ore is not sold, as such, and is almost entirely calcined before shipping to the refinery for conversion into the borax of commerce, it is difficult to arrive at a valuation of the crude ore mined. For this reason and the fact that the material varied widely in boric acid content, we have re-calculated the tonnage to a basis of 40% A. B. A. This is approximately the average A. B. A. content of the colemanite material after calcining, in which condition it is shipped to the refinery. A valuation of 50¢ per unit of 'anhydrous boric acid' was reported for the calcined material. Recalculated as above, the 1922 production totals 39,087 tons valued at $1,068,025.

Borax was first discovered in California in the waters of Tuscan Springs in Tehama County, January 8, 1856. Borax Lake, in Lake County, was discovered in September of the same year by Dr. John A. Veach. This deposit was worked in 1864–1868, inclusive, and during that time produced 1,181,365 pounds of refined borax. This was the first commercial output of this salt in the United States, and California

is still today the leading American producer of borax, having been for many years the sole producer.

Production from the dry lake 'playa' deposits of Inyo and San Bernardino counties began in 1873; but it was not until 1887 that the borax industry was revolutionized by the discovery of the colemanite beds at Calico, in San Bernardino County. These have since been largely worked out, and the output for a number of years has been coming from similar beds in Inyo and Los Angeles counties. In 1920 San Bernardino County again entered the field with shipments of such ore from near Daggett. The colemanite deposits of Ventura County are at present unworked, owing to lack of transportation facilities. Some production of colemanite is being made from deposits recently opened up in Clarke County, Nevada.

Colemanite is a calcium borate, and the material mined is mostly shipped to eastern chemical plants for refining. Refined 'borax' (sodium tetraborate) is used in making the enameled coating for cast-iron and steel-ware employed in plumbing fixtures, chemical equipment, and kitchen utensils. It is also a constituent of borosilicate glasses which are utilized in making lamp chimneys, baking dishes, and laboratory glassware. Other important uses of borax are in the manufacture of laundry and kitchen soaps, in starch, paper sizing, tanning, welding, and in the preparation of boric acid, which is employed as an antiseptic and in preserving meats.

Total Production of Borate Materials in California.

The total production of borate materials in California is shown in the following table:

Year	Tons	Value
1864	12	$9,478
1865	126	94,099
1866	201	132,538
1867	220	156,137
1868	32	22,384
1869	----------	----------
1870	----------	----------
1871	----------	----------
1872	140	89,600
1873	515	255,440
1874	915	259,427
1875	1,168	289,080
1876	1,437	312,537
1877	993	193,705
1878	373	66,257
1879	364	65,443
1880	609	149,245
1881	690	189,750
1882	732	201,300
1883	900	265,500
1884	1,019	198,705
1885	942	155,430
1886	1,285	173,475
1887	1,015	116,689
1888	1,405	196,636
1889	965	145,473
1890	3,201	480,152
1891	4,267	640,000
1892	5,525	838,787
1893	3,955	593,292
1894	5,770	$807,807
1895	5,959	595,900
1896	6,754	675,400
1897	8,000	1,080,000
1898	8,300	1,153,000
1899	20,357	1,139,882
1900	25,837	1,013,251
1901	22,221	982,380
1902	[a]17,202	2,234,994
1903	34,430	661,400
1904	45,647	698,810
1905	46,334	1,019,158
1906	58,173	1,182,410
1907	53,413	1,200,913
1908	22,200	1,117,000
1909	16,628	1,163,960
1910	16,828	1,177,960
1911	50,945	1,456,672
1912	42,135	1,122,713
1913	58,051	1,491,530
1914	62,500	1,483,500
1915	67,004	1,663,521
1916	103,523	2,409,375
1917	109,944	2,561,955
1918	88,772	1,867,908
1919	66,791	1,717,192
1920	127,065	2,794,206
1921	50,136	1,096,326
1922	[b]39,087	1,068,025
Totals	1,313,012	$44,927,710

[a]Refined borax. [b]Recalculated to 40% 'anhydrous boric acid' equivalent.

CALCIUM CHLORIDE.

Calcium chloride ($CaCl_2$) was reported for the first time to the State Mining Bureau as produced commercially, in 1921, from plants in San Bernardino County. It is obtained as a by-product in the refining of salt from deposits in certain of the desert dry lakes. The total for 1921 amounted to 683 tons, valued at $22,980. In 1922, there was a decrease in tonnage and value, as there was only a single operator; for this reason, also, the figures are concealed under the 'unapportioned' item.

Calcium chloride is hygroscopic, that is, it has an affinity for water. This property is taken advantage of by utilizing this salt as a drying agent. It is also sprinkled on dirt roads and playgrounds to keep down dust by absorbing moisture. In refrigerating machinery for ice factories, meat-packing houses and cold-storage warehouses, a calcium-chloride solution is stated to have some advantages over salt brine. In fire buckets this solution has an advantage over pure water, in that it has a lower freezing point, does not corrode metal, and tends to keep the buckets full due to its absorbing moisture from the atmosphere. Powdered calcium chloride is used in drying gases, fruits and vegetables.

MAGNESIUM SALTS.

Bibliography: Bulletin 91. 'Dictionary of Applied Chemistry,' by Thorpe. U. S. Geol. Surv., Min. Res. of U. S.

Magnesium chloride is an important item in certain chemical uses, and in the preparation of Sorel cement in laying magnesite floors. Previous to 1915, Germany was the principal source of this chloride. Some of the salt companies in California began its commercial preparation in 1916, from the residual bitterns obtained during the evaporation of sea water for its sodium chloride.

In addition to the chloride, some magnesium sulphate, or 'epsom salts,' has also been made at four of the plants: Oliver Chemical Company in Alameda County, Whitney Chemical Company in San Mateo County, the Marine Chemical Company at Long Beach, Los Angeles County, and the California Chemical Company at San Diego; though but two of them reported sales of the sulphate in 1922.

In 1922, the prices reported for the chloride ranged from $25 to $35 per ton, and the price for the sulphate averaged $45.

The 1922 output of chloride and sulphate totaled 3,036 tons, valued at $89,788, a decrease both in tonnage and value from the 1921 figures of 4,153 tons and $106,140.

With the use of magnesite cement and stucco coming more into vogue in building construction, the demand for magnesium chloride will increase in proportion.

Metallic magnesium is prepared generally by electrolysis of fused magnesium chloride in a bath of an alkaline chloride. In the United States, one plant uses a bath of salt and ammonium chloride. A plant at Niagara Falls uses calcined magnesite, the metal being reduced by electrolysis of the fused oxide in an electrolyte or bath of fused fluorides. The commonest known use of the metal is in the powdered form for flash lights in photography. During the war, magnesium

was put in shrapnel shells, that observers and gunners might know exactly where the shells were bursting. By day the burning magnesium gives a dense pure-white cloud of magnesium oxide, and at night a dazzling white light. Larger quantities were used in aerial bombs and rockets for lighting up the country at night. Magnesium has, as yet, found but a limited direct use as a metal. Magnalium, an alloy of aluminum containing about 2% of magnesium and small percentages of other metals, is stated to be used in automobiles and aeroplanes. The possibilities for further important developments in this direction are promising.

Total Production of Magnesium Salts in California.

The total production of magnesium salts in California since the beginning of the industry here, is shown in the following tabulation:

Year	Tons	Value
1916	851	$6,407
1917	1,064	34,973
1918	1,008	29,955
1919	1,616	82,457
1920	3,150	107,787
1921	4,153	106,140
1922	3,036	89,788
Totals	14,878	$457,507

NITRATES.

Bibliography: Report XV. Bulletins 24, 67, 91. U. S. G. S., Press Bulletin No. 373, July, 1918.

Nitrates of sodium, potassium and calcium have been found in various places in the desert regions of the state, but no deposit of commercial value has been developed as yet. It is hoped that a closer search may some day be rewarded by workable discoveries. At present the principal commercial source of nitrates is the Chilean saltpeter (sodium nitrate) deposits in South America.

The fixation of atmospheric nitrogen electrically has been accomplished successfully in Germany and Scandinavia. The possibilities of cheap hydro-electric power in California make the subject one of intense interest to us, as we have also the natural raw materials and chemicals to go with the power. Sodium and potassium cyanides can be made by fixation of atmospheric nitrogen electrically.

POTASH.

Bibliography: Reports XV, XVIII. Bulletins 24, 61. U. S. G. S., Min. Res. 1913, 1914, 1915. Senate Doc. No. 190, 62d Congress, 2d Session. Mining & Sci. Press, Vol. 112, p. 155; Vol. 114, p. 789.

Potash production began commercially in California in 1914, with a small yield from kelp. Considerable time and money has been spent on research work incident to developing deposits of potash-bearing residues and brines in the old lake beds of the desert regions, and

production there has been accomplished on a commercial basis at three plants on Searles Lake.

The imports of potash salts and fertilizers from Germany previous to the European war had an annual value of several millions of dollars, and their cessation made a domestic production imperative. The normal pre-war price of $35 to $40 per ton for high-grade agricultural salts was succeeded by figures of several times those amounts during the period of 1915-1920. Resumption of German imports since 1919 has forced the prices down, so that the reports of the 1922 Californian production show sales ranging from $18 to $52 per ton for salts carrying from 36% to 87% equivalent K_2O.

A consular report[1] shows the following annual figures of production of potash salts in Germany: 11,607,511 metric tons, 1913; 7,772,036 in 1919; 11,386,439 in 1920; 9,241,179 in 1921.

"The potassium salts produced in Germany in 1921 contained 1,066,849 tons of pure potash, or one-ninth of the weight of the salts. The potash production of Germany in 1921 is shown in the following table:

"GERMAN POTASH PRODUCTION IN 1921.

Items	Volume, kilos	Pure potash, kilos
"Fertilizing salts:		
18 to 22 per cent K_2O	329,081,300	46,382,000
28 to 32 per cent K_2O	88,693,200	26,977,900
38 to 42 per cent K_2O	752,312,200	305,202,500
"Chloride of potash:		
50 to 60 per cent K_2O	354,435,500	182,304,600
More than 60 per cent K_2O	77,685,800	48,441,100
"Sulphate of potash, containing more than 42 per cent K_2O	44,625,000	22,064,100
"Other potash	11,709,100	3,203,700

German potash salts are admitted free of duty into the United States.

During 1922, a total of 17,776 tons of potash-bearing materials of all grades was produced in California, valued at $584,388, compared with 14,806 tons, and $390,210 in 1921. This included refined potassium chloride from salt-works bitterns, chloride from Searles Lake brines and from kelp char, sulphate from cement dust, and molasses from distillery slops char. The only yield from kelp in 1922 was from the plant at Summerland, Santa Barbara County, formerly operated by the U. S. Department of Agriculture, but which has been sold to the U. S. Kelp-Products Company.

A report issued to its stockholders, November 22, 1922, by the American Trona Corporation[2] operating at Searles Lake, San Bernardino County, Cal., says that in spite of the disadvantage to the American producer due to the failure of the new tariff law to have included a duty on foreign potash, the company has

"lately been able to secure reductions in freight rates which will mean, on the present rate of its production, an economy of about $170,000 per annum on the transportation of its products. At the same time the price of fuel oil, which alone represents over 30 per cent of the production costs, has been reduced from $2.92 per barrel, the price at the beginning of last year, to $1.38 per barrel at the present time.

"The demand in the United States for both potash and borax has improved considerably during the last year. Though the price of borax has remained practically stationary, the price of foreign potash has increased from 64¢ net per unit of K_2O as

[1]Parmelee, Maurice, Germany: Trade and economic review for 1921, No. 35, Supplement to Commerce Reports, U. S. Dept. of Commerce, Jan. 1923.

[2]American Trona Corp.: Company reports, Eng. & Min. Jour., Vol. 114, p. 1096, Dec. 16, 1922.

prevailed last year, to 68¢ net per unit of K_2O this season, which increase represents an advance of about $2.25 per ton of our salts. The foreign prices are c.i.f. Atlantic coast ports, to which must be added freight to interior points of consumption. It will thus be seen that owing to the reduction of freight rates from the California plant to the East, also to the lowering of production costs on the one hand and to the increase in the price of potash on the other, the company is in a more favorable competitive position—its advantage increasing in direct ratio to the distance of the overland haul of foreign potash. This favorable position is particularly felt in the Middle West, which is geographically the corporations' natural sales area."

* * * * * * *

"Since the resumption of operations at Trona the weekly production of salts has steadily increased, and the cost of production has been steadily reduced at a gratifying rate, as is shown by the following comparative figures:

"PRODUCTION AND RELATIVE COSTS OF AMERICAN TRONA CORPORATION.

Production in tons of 2,000 lb.

Comparison first four months of—	Potash			Borax	
	Salts	Average grade in per cent	Potassium chloride content (100 per cent KCl)		Total tons potassium chloride and borax
1919	4,791	61	2,941	*	2,941
1920	3,369	89	3,019	1,430	4,499
1921	5,599	91	5,102	2,547	7,649
1922[a]	6,593	92.6	6,108	2,834	8,942

Comparison first four months of—	Fuel-oil consumption in gallons		Cost based on 1919 production costs as 100 per cent		
	Per ton potassium chloride produced	Per average ton potassium chloride and borax produced	Per ton potassium chloride produced	Per ton borax produced	Per average ton potassium chloride and borax produced
1919	1,647	*	100	*	100
1920	857	584	58.3	100	59.3
1921	417	279	32.6	54	33.4
1922[a]	371	253	24.4	40	24.9

[a]First four months in operation—May to August, 1922, inclusive.
*No borax produced."

The bulk of the 1922 potash output of California was utilized in fertilizer preparations, and some was sold for chemical purposes.

Other uses for potash salts, besides those noted above, are in the manufacture of the best liquid soap and some higher-grade cake soaps, of some finer grades of glass, and in matches. The chemical requirements included tanning, dyeing, metallurgy, electroplating, photography, and medicine.

Total Production of Potash in California.

The annual amounts and value of these potash materials since their beginning in California in 1914, are shown by the following table:

Year	Tons	Value
1914	10	$460
1915	1,076	19,391
1916	17,908	663,605
1917	129,022	4,202,889
1918	49,381	6,808,976
1919	28,118	2,415,963
1920	26,298	1,465,463
1921	14,806	390,210
1922	17,776	584,388
Totals	284,395	$16,557,345

SALT.

Bibliography: State Mineralogist Reports II, XII, XV, XVII, XVIII. Bulletins 24, 67, 91.

Most of the salt produced in California is obtained by evaporating the waters of the Pacific Ocean, plants being located on the shores of San Francisco Bay, Monterey Bay, Long Beach, and San Diego Bay. Additional amounts are derived from lakes and lake beds in the desert regions of the state. The salt production of San Bernardino County is in part derived from deposits of rock salt which are worked by means of quarrying and steam shovels. Some also is prepared by crystallization from the brines of Searles Lake, which are worked mainly for potash and borax. A small amount of valuable medicinal salts is

Harvesting salt at plant of Monterey Bay Salt Company, Moss Landing, Monterey County, California.

occasionally obtained in Mono and Tehama counties, by evaporation from Mono Lake and mineral springs respectively.

Formerly a considerable proportion of the table salt consumed in California was shipped in from Eastern points; but, at present, California salt refineries supply not only our own needs but export a fair tonnage to other markets.

It may appear at first thought superfluous to enumerate the uses of so well-known an item as 'common' salt, one whose history antedates the written page; but it is employed for many purposes other than culinary. A bulletin of the U. S. Geological Survey states that there is produced annually in the United States sufficient salt to supply each one of the 106,000,000 inhabitants with at least 150 pounds apiece. Besides its culinary uses, salt is employed in packing meat, curing fish and hides, dairying, refrigerating, preserving products from deterioration, pottery

glazing, enameling, pickle making, salting live stock, and in some chemical industries, as in preparing soda ash and caustic soda.

Distribution of the 1922 salt production of California, by counties, was as follows:

County	Tons	Value
Alameda	139,556	$434,076
Kern	18,000	66,000
San Bernardino	12,222	54,259
San Mateo	32,428	149,302
Los Angeles, Modoc, Mono,[a] Monterey, San Diego*	21,032	115,550
Totals	223,238	$819,187

[a]Medicinal salts. *Combined to conceal output of a single operator in each.

The above returns show an increase in tonnage but a decrease in value from the 1921 figures of 197,989 tons and $832,702. In 1922 there were ten plants operating in Alameda County, and a total of twelve plants in the other counties tabulated.

Production of Salt in California, by Years.

Amount and value of annual production of salt in California from 1887 is shown in the following tabulation:

Year	Tons	Value	Year	Tons	Value
1887	28,000	$112,000	1906	101,650	$213,228
1888	30,800	92,400	1907	88,063	310,967
1889	21,000	63,000	1908	121,764	281,469
1890	8,729	57,085	1909	155,680	414,708
1891	20,094	90,303	1910	174,920	395,417
1892	23,570	104,788	1911	173,332	324,255
1893	50,500	213,000	1912	185,721	383,370
1894	49,131	140,087	1913	204,407	462,681
1895	53,031	150,576	1914	223,806	583,553
1896	64,743	153,244	1915	169,028	368,737
1897	67,851	157,520	1916	186,148	455,695
1898	93,421	170,855	1917	227,825	584,373
1899	82,654	149,588	1918	212,076	806,328
1900	89,338	204,754	1919	233,994	896,963
1901	126,218	366,376	1920	230,638	972,648
1902	115,208	205,876	1921	197,989	832,702
1903	102,895	211,365	1922	223,238	819,187
1904	95,968	187,300			
1905	77,118	141,925	Totals	4,310,548	$12,078,323

SODA.

Bibliography: State Mineralogist Reports XII, XIII, XV, XVII, XVIII. Bulletins 24, 67, 91. U. S. Geol. Surv., Bull. 717.

The production of carbonates of sodium in California in 1922 included soda ash from plants at Owens Lake, Inyo County, and crude 'trona' from Searles Lake, San Bernardino County. There were no shipments in 1921-1922 of sulphate from the deposit on Carrizo Plains, San Luis Obispo County. The total amounted to 20,084 tons, valued at $573,661, being an increase over the output of 1921, which was 14,828 tons, worth $438,996. For the current year, 1923, shipments are being made from a deposit of the anhydrous sulphate (thenardite) at Bertram station in the Salton Sea basin, Imperial County.

These 'sodas' produced in California have been used in the manufacture of glass, soap, and paper, as well as for washing and baking soda, in sugar refining, and in various chemical industries. The crude trona shipped was used for neutralizing in flotation concentration in place of soda ash. For several years a portion of California's product was exported, but since the latter part of 1920, the export demand has fallen off.

'Salt Cake' deposit (mainly thenardite, anhydrous sodium sulphate), at Bertram station in the Salton Basin, Imperial County. Photo by E. N. Smith.

Sodium compounds are replacing potassium compounds, either wholly or in part, in glass and soap making, in photography, in match making, in tanning, and in the manufacture of cyanide for extracting gold and silver from their ores.

Soda Production of California, by Years.

The total output, showing amount and value of these materials in California since the inception of the statistical records of the State Mining Bureau, is given in the table which follows:

Year	Tons	Value	Year	Tons	Value
1894	1,530	$20,000	1909	7,712	$11,593
1895	1,900	47,500	1910	8,125	11,862
1896	3,000	65,000	1911	9,023	52,887
1897	5,000	110,000	1912	7,200	37,094
1898	7,000	154,000	1913	1,861	24,936
1899	10,000	250,000	1914	6,522	115,396
1900	1,000	50,000	1915	5,799	83,485
1901	8,000	400,000	1916	10,593	264,825
1902	7,000	50,000	1917	24,505	928,578
1903	18,000	27,000	1918	20,447	855,423
1904	12,000	18,000	1919	21,294	721,958
1905	15,000	22,500	1920	32,407	1,164,898
1906	12,000	18,000	1921	14,828	438,996
1907	-----	-----	1922	20,084	573,661
1908	9,600	14,400	Totals	301,430	$6,531,992

CHAPTER SEVEN.

BY COUNTIES.

Introductory.

The State of California includes a total area of 158,360 square miles, of which 155,980 square miles are of land. The maximum width is 235 miles, the minimum, 148 miles; and the length from the northwest corner to the southeast corner is 775 miles. The state is divided into fifty-eight counties. The 1920 census figures show a total population for California of 3.437,709. Minerals of commercial value exist in every county, and during 1922 some active production was reported to the State Mining Bureau from all of the fifty-eight.

Of the first ten counties in point of total output for 1922, the first four (Kern, Los Angeles, Orange, Fresno) owe their position mainly to petroleum, as do also Ventura (sixth), and Santa Barbara (seventh). Kern, due to its oil, leads all the others though challenged by Los Angeles, its nearest competitor. San Bernardino owes its place chiefly to cement, silver, potash, and borax; Riverside to cement, brick and tile; Santa Cruz to cement; Plumas to copper. Twenty-two counties have each a total in excess of a million dollars, for 1922. Cement is an important item in seven of these counties. In point of variety and diversity, San Bernardino County led all the others in 1922, with a total of 19 different mineral products on its commercial list, followed by San Diego with 18; Inyo with 17; Los Angeles with 15; Kern, Placer and Riverside, 13 each; Shasta, 12; Santa Barbara, 11; Fresno, 10; Calaveras, Imperial, Nevada, Santa Clara, and Tuolumne, 9 each. The counties with their mineral resources, production for 1922, etc., are considered in detail in the following paragraphs.

Value of California's Mineral Production by Counties, for 1922. Arranged in the Order of Their Importance.

County	Value	County	Value
1. Kern	$68,551,002	31. Marin	$403,099
2. Los Angeles	62,751,671	32. Tulare	371,845
3. Orange	38,926,087	33. Napa	312,270
4. Fresno	10,853,433	34. Monterey	255,319
5. San Bernardino	8,547,900	35. San Mateo	243,984
6. Ventura	5,837,078	36. Mariposa	226,832
7. Santa Barbara	4,613,358	37. Sonoma	221,941
8. Santa Cruz	3,608,805	38. Trinity	197,937
9. Plumas	3,314,498	39. Imperial	188,739
10. Riverside	3,243,917	40. El Dorado	184,525
11. Solano	3,108,114	41. Merced	157,579
12. Nevada	2,966,005	42. San Luis Obispo	141,470
13. Yuba	2,588,316	43. Humboldt	125,613
14. Amador	2,479,063	44. Siskiyou	101,463
15. Contra Costa	2,397,312	45. Glenn	91,250
16. Sacramento	2,189,562	46. Mono	86,863
17. Inyo	2,137,681	47. Colusa	75,934
18. Alameda	2,041,454	48. San Francisco	65,409
19. San Benito	1,794,248	49. Lake	48,289
20. Sierra	1,770,626	50. Lassen	27,327
21. Shasta	1,513,591	51. Mendocino	20,526
22. Calaveras	1,502,883	52. Modoc	16,018
23. Santa Clara	894,036	53. Yolo	13,431
24. Butte	720,625	54. Tehama	9,388
25. Tuolumne	761,938	55. Kings	6,806
26. San Diego	656,807	56. Del Norte	6,261
27. Madera	476,264	57. Alpine	2,800
28. San Joaquin	473,395	58. Sutter	97
29. Stanislaus	452,167		
30. Placer	405,975	Total	$245,183,826

ALAMEDA.

Area: 843 square miles.
Population: 344.177 (1920 census).

Alameda County, while in no sense one of the 'mining counties,' comes eighteenth on the list with a value of mineral products for 1922 of $2.041.454, an increase over the 1921 total, which was $1.353.690. The mineral resources of this county include asbestos, brick, chromite, clay, coal, limestone, magnesite, manganese, pyrite, salt, soapstone, and miscellaneous stone.

Commercial production for 1922 was as follows:

Substance	Amount	Value
Clay and clay products		$777,354
Manganese ore	130 tons	1,020
Salt	139,556 tons	434,076
Stone, miscellaneous		760,422
Other minerals*		68,582
Total value		$2,041,454

*Includes magnesium salts, and pyrites.

ALPINE.

Area: 776 square miles.
Population: 243 (1920 census).

Alpine has in the past shown a small production of gold and silver, but dropped out of the list of producing counties in 1914–1918. For 1922, a total value of $2,800 was reported, as follows:

Substance	Value
Stone, miscellaneous	$2,800

This county lies just south of Lake Tahoe, in the high Sierra Nevada range of mountains. Transportation is by auto, wagon, or mule back, and facilities in general are lacking to promote development work of any kind.

The mineral resources of this section are varied and the country has not yet been thoroughly prospected. Occurrences of barium, copper, gold, gypsum, lead, limestone, pyrite, rose quartz, silver, tourmaline, and zinc have been noted here.

AMADOR.

Area: 601 square miles.
Population: 7,793 (1920 census).

The value of Amador County's mineral production increased from $2,368,464 in 1921, to $2,479,063, placing it number fourteen on the list of counties in the state as regards total value of mineral substances marketed. The advance was due to an increase in clay products and gold output.

Although having an output consisting of 8 different minerals, the leading product, gold, makes up approximately 91% of the entire total.

Amador at one time led the state in gold production, but was exceeded in 1920–1922 by Yuba and Nevada counties.

The mineral resources of this county include asbestos, brick, chromite, clay, coal, copper, gold, lime, quartz crystals, glass-sand, sandstone, silver, soapstone, and miscellaneous stone.

Commercial production for 1922 was as follows:

Substance	Amount	Value
Clay (pottery)	39,572 tons	$68,126
Gold		2,241,100
Silica	865 tons	5,030
Silver		32,287
Stone, miscellaneous		7,300
Other minerals*		125,220
Total value		$2,479,063

*Includes brick and platinum.

BUTTE.

Area: 1,722 square miles.
Population: 30,030 (1920 census).
Location: North-central portion of state.

Butte, twenty-fourth county in California in regard to the value of its mineral output, reported a commercial production of eight mineral substances, having a total value of $720,625 as compared with $669,830 in 1920. As will be noted in the following tabulation, gold is by far the most important item. Butte stands seventh among the gold-producing counties of the state. Among the mineral resources of this section are asbestos, barytes, chromite, gems, gold, limestone, marble, mineral water, platinum group, silver, and miscellaneous stone.

Commercial value for 1922 was as follows:

Substance	Amount	Value
Diamonds		$225
Gold		491,201
Mineral water	2,835 gals.	2,485
Platinum	30 fine oz.	3,826
Silver		1,890
Stone, miscellaneous		220,450
Other minerals		548
Total value		$720,625

CALAVERAS.

Area: 1,027 square miles.
Population: 6,183 (1920 census).
Location: East-central portion of state—Mother Lode district.

Calaveras County reported production of 9 different minerals, valued at $1,502,883 during the year 1922 as compared with the 1921 output at $1,525,201. Gold, copper, and silver are the chief mineral substances. In regard to total value of mineral output, Calaveras stands twenty-second among the counties of the state, and fifth in gold. The decrease, as compared with 1921, is due mainly to gold.

The principal mineral resources developed and undeveloped are: Asbestos, chromite, clay, copper, fullers' earth, gold, limestone, marble, mineral paint, mineral water, platinum group, pyrite, quartz crystals, silver, soapstone, and miscellaneous stone.

Commercial output for 1922 was as follows:

Substance	Amount	Value
Gold		$1,413,465
Mineral water	1,914 gal.	639
Platinum	22 fine oz.	2,150
Silver		11,648
Stone, miscellaneous		35,590
Other minerals*		39,391
Total value		$1,502,883

*Includes clay (pottery), copper, gems.

COLUSA.

Area: 1.140 square miles.
Population: 9.920 (1920 census).
Location: Sacramento Valley.

Colusa County lies largely in the basin of the Sacramento Valley. Its western border, however, rises into the foothills of the Coast Range of mountains, and its mineral resources—largely undeveloped—include coal, chromite, copper, gypsum, manganese, mineral water, pyrite, quicksilver, sandstone, miscellaneous stone, sulphur, and in some places traces of gold and silver.

The value of the 1922 production was $75,934, a decrease from the 1921 figures of $80,438, giving it forty-seventh place, and was as follows:

Substance	Value
Unapportioned*	$75,934

*Includes gold, mineral water, silver, miscellaneous stone.

CONTRA COSTA.

Area: 714 square miles.
Population: 53,889 (1920 census).

Contra Costa, like Alameda County, lies on the eastern shores of San Francisco Bay, and is not commonly considered among the mineral-producing counties of the state. It stands fifteenth on the list in this respect, however, with an output valued at $2,397,312 for the calendar year 1922. Various structural materials make up the chief items, including brick, cement, limestone, and miscellaneous stone. Among the others are asbestos, clay, coal, gypsum, manganese, mineral water, and soapstone.

Commercial production for 1922 was as follows:

Substance	Amount	Value
Brick and tile		$307,749
Clay (pottery)	7,086 tons	12,910
Stone, miscellaneous		559,915
Other minerals*		1,516,738
Total value		$2,397,312

*Includes cement, limestone, mineral water.

DEL NORTE.

Area: 1,024 square miles.
Population: 2,759 (1920 census).
Location: Extreme northwest corner of state.
Transportation: Motor, wagon and mule back; steamer from Crescent City.

Del Norte rivals Alpine County in regard to inaccessibility. Like the latter county also, given transportation and kindred facilities, this portion of the state presents a wide field for development along mining lines especially. Its chief mineral resources, largely untouched, are chromite, copper, gems, gold, iron, platinum group, silver, and miscellaneous stone. The 1922 output was a slight increase over the figure of $6,029 in 1921.

Commercial production for 1922, giving it fifty-sixth place, was as follows:

Substance	Value
Stone, miscellaneous	$5,500
Other minerals*	761
Total value	$6,261

*Includes gold, platinum, silver.

EL DORADO.

Area: 1,753 square miles.
Population: 6,426 (1920 census).
Location: East-central portion of the state, northernmost of the Mother Lode counties.

El Dorado County, which contains the locality where gold in California was first heralded to the world, comes fortieth on the list of counties ranked according to the value of their total mineral production during the year 1922. In addition to the segregated figures here given, a large tonnage of limestone is annually shipped from El Dorado for use in cement manufacture, and whose value is included in the state total for cement. The increase over the 1921 figure of $112,756 was due mainly to limestone.

The mineral resources of this section, many of them undeveloped, include asbestos, barytes, chromite, clay, copper, gems, gold, iron, molybdenum, limestone, quartz crystals, quicksilver, slate, soapstone, silver, and miscellaneous stone.

Commercial production for 1922 was as follows:

Substance	Amount	Value
Gold		$47,340
Limestone	42,200 tons	113,709
Silver		376
Stone, miscellaneous		4,250
Other minerals*		18,850
Total value		$184,525

*Includes slate and soapstone.

FRESNO.

Area: 5,950 square miles.
Population: 128,779 (1920 census).
Location: South-central portion of state.

Fresno County, fourth in importance as a mineral producer among the counties of California, reported an output for 1922 of ten mineral substances, with a total value of $10,853,433, a decrease from the reported 1921 production, which was worth $19,498,503. The bulk of the above is derived from the petroleum production of the Coalinga field.

The mineral resources of this county are many, and, aside from crude oil, are in the main not yet fully developed. They include asbestos, barytes, brick, chromite, copper, gems, gold, graphite, gypsum, magnesite, natural gas, petroleum, quicksilver, and miscellaneous stone.

Commercial production for 1922 was as follows:

Substance	Amount	Value
Brick and tile		$220,737
Gold		10,442
Granite		28,600
Natural gas	1,694,090 M. cu. ft.	89,277
Petroleum	9,265,529 bbls.	9,895,582
Silver		87
Stone, miscellaneous		600,348
Other minerals		8,360
Total value		$10,853,433

GLENN.

Area: 1,259 square miles.
Population: 11,853 (1920 census).
Location: West side of Sacramento Valley.

Glenn County, standing forty-fifth, owes its position among the mineral-producing counties of the state mainly to the presence of large deposits of sand and gravel which are annually worked, the product being used for railroad ballast, etc. In 1917 and 1918, chromite was also an important item. In the foothills in the western portion of the county, deposits of chromite, copper, manganese, sandstone, and soapstone have been found.

Commercial production for 1922 was as follows.

Substance	Value
Stone, miscellaneous	$91,250

HUMBOLDT.

Area: 3,634 square miles.
Population: 37,857 (1920 census).
Location: Northwestern portion of state, bordering on Pacific Ocean.

Humboldt County is almost entirely mountainous, transportation within its limits being very largely by auto and wagon road, and trail, and until recent years was reached from the outside world by steamer

only. The county is rich in mineral resources, among which are brick, chromite, coal, clay, copper, gold, iron, mineral water, natural gas, petroleum, platinum, silver, and miscellaneous stone.

Nine mineral substances, as shown by the table given below, having a total value of $125,613, were produced in 1922, as compared with the 1921 output, worth $138,597, the decrease being due mainly to miscellaneous stone. Humboldt ranks forty-third among the counties of the state for the year.

Commercial production for 1922 was as follows:

Substance	Amount	Value
Brick and clay (pottery)		$6,399
Gold		1,330
Platinum	4 fine oz.	413
Silver		10
Stone, miscellaneous		117,308
Other minerals*		153
Total value		$125,613

*Includes mineral water and natural gas.

IMPERIAL.

Area: 4,089 square miles.
Population: 43,383 (1920 census).
Location: Extreme southeast corner of the state.

During 1922 Imperial County produced nine mineral substances having a total value of $188,739, as compared with the 1921 output, worth $182,818. Its rank is thirty-ninth. This county contains deposits of gold, gypsum, lead, marble, pumice, salt, silver, and strontium, largely undeveloped.

Commercial production for 1922 was as follows:

Substance	Value
Gold	$350
Silver	18,924
Stone, miscellaneous	154,560
Other minerals*	15,805
Total value	$188,739

*Includes brick, gypsum, lead, marble, pumice.

INYO.

Area: 10,019 square miles.
Population: 7,031 (1920 census).
Location: Lies on eastern border of state, north of San Bernardino County.

Inyo, the second largest county in the state, and containing less than one inhabitant per square mile, is extremely interesting from a mineralogical point of view. It is noted because of the fact that within its borders are located both the highest point, Mount Whitney (elevation 14,502 feet), and the lowest point, Death Valley (elevation 290 feet below sea level), in the United States. In the higher mountainous sections are found many vein-forming minerals, and in the lake beds of Death Valley saline deposits exist.

Inyo's mineral production during the year 1922 reached a value of $2,137,681, standing seventeenth among the counties of the state in this respect. The 1921 value was $1,460,218, the increase being due mainly to lead, silver, and soda. Its mineral resources include antimony, asbestos, barytes, borax, copper, gems, gold, gypsum, lead, marble, soda, sulphur, talc, tungsten, and zinc.

Commercial production was as follows:

Substance	Amount	Value
Copper	69,537 lbs.	$9,388
Dolomite	43,778 tons	72,284
Gold		85,265
Lead	6,264,138 lbs.	341,528
Silver		256,009
Stone, miscellaneous		12,000
Other minerals*		1,358,207
Total value		$2,137,681

*Includes borates, building stone, clay (pottery), fuller's earth, limestone, marble, pumice, soda, talc, zinc.

KERN.

Area: 8,003 square miles.
Population: 54,843 (1920 census).
Location: South-central portion of state.

Kern County, because of its immensely productive oil fields, stands preeminent among all counties of California in the value of its mineral output, the exact figures for 1922 being $68,551,002. This is approached only by Los Angeles County in 1922, for which petroleum is also responsible. This figure is more than four times the value of the total gold output of the entire state for 1922. The 1921 mineral output for Kern County was worth $100,840,933. The decrease was due to the lower prices for crude oil of all grades, and to the fact that a large number of wells in the San Joaquin valley fields were 'shut in' owing to the over-production of high-gravity oil in the new gusher fields of the Los Angeles basin.

Among the mineral resources, developed and undeveloped, of this section are: Antimony, asphalt, borax, brick, clay, copper, fuller's earth, gems, gold, gypsum, iron, lead, limestone, magnesite, marble, mineral paint, natural gas, petroleum, potash, salt, silver, soapstone, soda, sulphur, and tungsten.

Commercial production for 1922 was as follows:

Substance	Amount	Value
Brick	5,082 M	$66,652
Gold		124,337
Natural gas	47,644,633 M. cu. ft.	2,282,100
Petroleum	53,512,157 bbls.	64,803,222
Salt	18,000 tons	66,000
Silver		6,524
Stone, miscellaneous		35,585
Other minerals*		1,166,582
Total value		$68,551,002

*Includes cement, copper, lead, lime, silica.

KINGS.

Area: 1,159 square miles.
Population: 22,031 (1920 census).
Location: South-central portion of the state.

Little development has taken place in Kings County along mineral lines to date. Deposits of fuller's earth, gypsum, mineral paint, natural gas, and quicksilver, of undetermined extent, have been found in the county. Some drilling for oil has been under way, but there has, as yet, been no commercial output recorded.

Tulare Lake is in Kings County.

In fifty-fifth place, commercial mineral production in this county for 1922 was as follows:

Substance	Amount	Value
Natural gas	1,790 M. cu. ft.	$870
Other minerals		5,936
Total value		$6,806

LAKE.

Area: 1,278 square miles.
Population: 5,542 (1920 census).
Location: About fifty miles north of San Francisco Bay and the same distance inland from the Pacific Ocean.

On account of its topography and natural beauties, Lake County is sometimes referred to as the Switzerland of America. The mineral resources which exist here are many and varied, actual production being comparatively small, as shown by the table below, and in the past composed mainly of quicksilver, and mineral water. Some of the leading minerals found in this section, in part as yet undeveloped, are borax, chromite, clay, copper, gems, gold, gypsum, mineral water, quicksilver, silver, and sulphur.

In fortieth place, commercial production for 1922 was as follows:

Substance	Amount	Value
Mineral water	60,420 gals.	$29,370
Quicksilver	38 flasks	2,000
Stone, miscellaneous		16,669
Other minerals		250
Total value		$48,289

LASSEN.

Area: 4,531 square miles.
Population: 8,507 (1920 census).
Location: Northeast portion of state.

Lassen County is one of the little-explored sections of California. Since about 1912 a railroad traversing the county north and south has been in operation, thus affording opportunity for development along mineral and other lines.

Among the mineral resources of this county are copper, gems, gypsum, gold, silver, and sulphur. In the past, some gold had been

produced, but not for some years, until 1921, when the yield again became important.

In fiftieth place, commercial production for 1922 was as follows:

Substance	Value
Stone, miscellaneous	$9,450
Other minerals*	17,877
Total value	$27,327

*Includes brick, gold, silver.

LOS ANGELES.

Area: 4,067 square miles.
Population: 936,438 (1920 census).
Location: One of the southwestern coast counties.

Mineral production in Los Angeles County for the year 1922 amounted in value to $62,751,671 as compared with the 1921 output, worth $31,704,941. This county ranked second in the state as a mineral producer in 1922, having passed Orange County which has been second for several years. The advance was due mainly to the large increase in the petroleum yield, and in part to an increase in the output of bricks, building tile, natural gas, and miscellaneous stone.

Its output of brick and tile was over four million dollars, and that of petroleum amounted to nearly fifty-three million dollars. Among the mineral resources may be noted asphalt, barytes, borax, brick, clay, fuller's earth, gems, gold, gypsum, infusorial earth, limestone, marble, mineral paint, mineral water, natural gas, petroleum, salt, glass-sand, sandstone, serpentine, silver, soapstone, and miscellaneous stone. Some potash has been obtained from kelp.

Commercial production for 1922, consisting of 15 substances, was as follows:

Substance	Amount	Value
Brick	240,424 M.	$4,190,185
Building tile	39,095 tons	397,136
Clay (pottery)	54,924 tons	66,519
Limestone	12,096 tons	35,168
Mineral water	300,400 gals.	15,450
Natural gas	23,254,549 M.	1,653,571
Petroleum	37,726,367 bbls.	52,930,093
Stone, miscellaneous		3,390,477
Other minerals*		72,772
Total value		$62,751,671

*Includes borates, gold, graphite, magnesium salts, salt, silver.

MADERA.

Area: 2,112 square miles.
Population: 12,203 (1920 census).
Location: East-central portion of state.

Madera County produced six mineral substances during the year 1922, having a total value of $476,264, as compared with the 1921 output worth $467,667. This county contains deposits of copper, gold, iron, lead, molybdenum, pumice, silver, and building stone.

In twenty-seventh place, commercial production for 1922 was as follows:

Substance	Value
Gold	$1,594
Granite	454,222
Silver	3,500
Stone, miscellaneous	16,948
Total value	$476,264

MARIN.

Area: 529 square miles.
Population: 27,342 (1920 census).
Location: Adjoins San Francisco on the north.

Mineral production in Marin County during the year 1922 reached a value of $403,099, as compared to the 1921 output, worth $318,776, the increase being due to crushed rock, and brick. This county is not especially prolific in minerals, although among its resources along these lines are brick, gems, manganese, mineral water, soapstone, and miscellaneous stone.

In thirty-first place, commercial production for 1922 was:

Substance	Value
Unapportioned*	$403,099

*Includes brick, mineral water, potash, miscellaneous stone.

MARIPOSA.

Area: 1,463 square miles.
Population: 2,775 (1920 census).
Location: Most southerly of the Mother Lode counties. East-central portion of state.

Mariposa County is one of the distinctly 'mining' counties of the state, although it stands but thirty-sixth on the list of counties in regard to the value of its mineral output for 1922, with a total of $226,832, as compared with the 1921 figure of $342,601, the decrease being due to gold.

Its mineral resources are varied; among the more important items being barytes, copper, gems, gold, lead, marble, silver, slate, soapstone, and miscellaneous stone.

The Yosemite Valley is in Mariposa County.

Commercial production in 1922 was as follows:

Substance	Value
Gold	$218,571
Silver	3,301
Stone, miscellaneous	2,000
Other minerals*	2,960
Total value	$226,832

*Includes barytes and pyrites.

MENDOCINO.

Area: 3,453 square miles.
Population: 24,116 (1920 census).
Location: Joins Humboldt County on the south and bounded by the Pacific Ocean on the west.

Mendocino's annual mineral production has usually been small, the 1922 output being valued at $20,526, ranking it fifty-first among the counties. That of 1921 was worth $44,722.

Deposits of in part undetermined value of asbestos, chromite, coal, copper, graphite, magnesite, and mineral water have been found, as well as traces of gold, platinum, and silver.

Commercial production for 1922 was as follows:

Substance	Value
Stone, miscellaneous	$18,726
Other minerals*	1,800
Total value	$20,526

*Includes brick, natural gas, platinum.

MERCED.

Area: 1,995 square miles.
Population: 24,579 (1920 census).
Location: About the geographical center of the state.

Merced County as a whole lies in the San Joaquin Valley, and it figures as one of the lesser mineral producing counties of the state. The 1922 mineral output was valued at $157,579 compared with $33,550 in 1921, the increase being due to tile and miscellaneous stone. Gold, platinum, and silver were formerly obtained by dredging, which ceased in this county in 1918, though a small yield from other sources still continues. Undeveloped deposits of antimony, magnesite, quicksilver, and limestone have been noted in this county in addition to the foregoing.

In forty-first place, commercial production during 1922 was as follows:

Substance	Value
Stone, miscellaneous	$88,110
Other minerals*	69,469
Total value	$157,579

*Includes building tile, gold, and silver.

MODOC.

Area: 3,823 square miles.
Population: 5,425 (1920 census).
Location: The extreme northeast corner of the state.

Modoc County, like Lassen, has only in recent years had the benefit of communication with the outside world by rail. Among its known mineral resources are: Clay, coal, gold, iron, quicksilver, salt, and

silver. In fifty-second place, commercial production for 1922 was as follows:

Substance	Value
Unapportioned*	$16,018

*Includes salt and miscellaneous stone.

MONO.

Area: 3,030 square miles.
Population: 960 (1920 census).
Location: Is bordered by the State of Nevada on the east and is about in the central portion of the state measured on a north and south line.

Gold mining has been carried on in portions of Mono County for many years, although taken as a whole it lies in a somewhat inaccessible country so far as rail transportation is concerned. It is in the continuation of the highly mineralized belt which was noted in Inyo County and contains among other mineral resources barytes, clay, copper, gold, limestone, molybdenum, pumice, salt, silver, and travertine.

In forty-sixth place, commercial production for 1922 was as follows:

Substance	Amount	Value
Copper	4,338 lbs.	$586
Gold		65,747
Lead	9,820 lbs.	540
Silver		11,686
Other minerals*		8,301
Total value		$86,863

*Includes onyx, salt, sillimanite.

MONTEREY.

Area: 3,330 square miles.
Population: 27,980 (1920 census).
Location: West-central portion of state, bordering on Pacific Ocean.

Monterey County produced eight mineral substances during the year 1922, having a total value of $255,319, as compared with the 1921 output worth $170,155, the increase being due to coal. Its mineral resources include brick, clay, copper, coal, dolomite, feldspar, fuller's earth, gold, silver, gypsum, infusorial earth, limestone, mineral water, petroleum, quicksilver, glass-sand, sandstone, silver, and miscellaneous stone.

In thirty-fourth place, commercial production for 1922 was as follows:

Substance	Value
Stone, miscellaneous†	$86,180
Other minerals*	169,139
Total value	$255,319

†Includes molding, building, blast, filter, and roofing sand.
*Includes asbestos, coal, dolomite, quicksilver, salt, silica (glass sand).

NAPA.

Area: 783 square miles.
Population: 20,678 (1920 census).
Location: Directly north of San Francisco Bay—one of the 'bay counties.'

Napa, because of its production of structural and industrial materials and mineral water, stands thirty-third on the list of mineral-producing counties in California. Its mineral resources include chromite, copper, gypsum, magnesite, mineral water, quicksilver, sandstone, and miscellaneous stone. In the past this county has been one of the important producers of quicksilver.

In 1922, the value of the output increased to $312,270 over the 1921 figure of $195,239, due mainly to miscellaneous stone.

Commercial production for 1922 was as follows:

Substance	Amount	Value
Mineral water	80,481 gals.	$54,341
Quicksilver	89 flasks	5,143
Stone, miscellaneous		200,151
Other minerals*		52,635
Total value		$312,270

*Includes building stone (red tuff) and magnesite.

NEVADA.

Area: 974 square miles.
Population: 10,860 (1920 census).
Location: North of Lake Tahoe, on the eastern border of the state.

Nevada, one of the mountain counties of California, for some years alternated with Amador in the gold lead, but both were passed by Yuba in 1918-1921. In 1922, Nevada regained the lead. Nevada County stands twelfth on the list in regard to value of its total mineral output, with a figure of $2,966,005, as compared with the 1921 production worth $2,641,081. The increase is due mainly to gold.

While this county actually produces mainly gold and silver, its resources cover a wide scope, including antimony, asbestos, barytes, bismuth, chromite, clay, copper, gems, iron, lead, mineral paint, pyrite, soapstone, and tungsten.

Commercial production for 1922 was as follows:

Substance	Value
Gold	$2,903,573
Silver	19,583
Stone, miscellaneous	27,982
Other minerals*	14,867
Total value	$2,966,005

*Includes barytes, copper, granite, lead, mineral paint.

ORANGE.

Area: 795 square miles.
Population: 61,375 (1920 census).
Location: Southwestern portion of state, bordering Pacific Ocean.

Orange County is one of the many in California which on casual inspection appears to be anything but a mineral-producing section. It has stood for several years, however, as the second county in the state in regard to the total value of mineral output, its highly productive oil fields making such a condition possible. It was passed in 1922 by Los Angeles, the credit for which is also due to oil.

Owing to the lower prices for oil this county shows a decrease in 1922, with a total value of mineral products of $38,926,087, compared to the 1921 output, worth $47,499,030. Orange passed Shasta County in 1917, which previously for a number of years had exceeded all other counties in California, except Kern.

Aside from the substances actually produced and noted in the table below, coal, gypsum, iron, infusorial earth, sandstone, and tourmaline have been found in Orange County.

Commercial production for 1922 was as follows:

Substance	Amount	Value
Brick	4,706 M.	$73,106
Natural gas	25,269,402 M. cu. ft.	2,096,629
Petroleum	31,049,491 bbls.	36,483,162
Stone, miscellaneous		270,022
Other minerals*		3,168
Total value		$38,926,087

*Includes clay (pottery), gold, lead, silver.

PLACER.

Area: 1,395 square miles.
Population: 18,584 (1920 census).
Location: Eastern border of state directly west of Lake Tahoe.

While standing only thirtieth on the list of mineral-producing counties, Placer contains a wide variety of mineral substances, some of which have not been commercially exploited. Its leading products include gold, chromite, granite, copper, and clay. Other mineral resources are: Asbestos, brick, coal, gems, iron, lead, limestone, magnesite, manganese, marble, quartz crystals, glass-sand, silver, and miscellaneous stone.

Commercial production for 1922 was as follows, compared to a total value of $449,070 for the preceding year:

Substance	Amount	Value
Brick and tile		$118,797
Clay (pottery)	79,531 tons	111,166
Gold		119,673
Granite		12,980
Silica	2,000 tons	5,500
Silver		952
Stone, miscellaneous		24,430
Other minerals*		12,477
Total value		$405,975

*Includes chromite, mineral paint, mineral water.

PLUMAS.

Area: 2,594 square miles.
Population: 5,681 (1920 census).
Location: Northeastern border of state, south of Lassen County.

A considerable portion of the area of Plumas County lies in the high mountains, and deposits of the metals, especially gold and copper, are found there. Lack of transportation and other facilities has retarded its growth, but its future is promising. Mineral production for 1922 was valued at $3,314,498, as compared with the 1921 output, worth $1,798,461, the increase being due mainly to copper, with accompanying increases in gold and silver. This placed the county ninth in rank. In 1919 Plumas passed Shasta in the copper lead, owing to the Shasta smelters being closed down, which position Plumas still retains.

Among its mineral resources are: Chromite, copper, gold, granite, iron, lead, limestone, manganese, molybdenum, platinum, silver, and zinc.

Commercial production for 1922 was as follows:

Substance	Amount	Value
Copper	20,677,771 lbs.	$2,791,499
Gold		223,025
Silver		297,254
Other minerals*		2,720
Total value		$3,314,498

*Includes granite, platinum, miscellaneous stone.

RIVERSIDE.

Area: 7,240 square miles.
Population: 60,297 (1920 census).
Location: Southern portion of state.

Riverside is the fourth county in the state in size and the tenth in regard to the total value of mineral output for 1922. Within its borders are included mountain, desert, and agricultural land. Its mineral resources include metals, structural and industrial materials, and salines, some of the more important being brick, cement, clay, coal, copper, feldspar, gems, gold, gypsum, iron, lead, limestone, manganese, magnesite, marble, mineral paint, mineral water, salt, soapstone, silver, miscellaneous stone, and tin. In point of variety Riverside County showed thirteen different minerals commercially produced in 1922.

The decrease in 1922 from the 1921 value of $4,883,989 was due mainly to lower prices for cement.

Commercial production for 1922 was as follows:

Substance	Amount	Value
Brick and tile		$535,772
Clay (pottery)	81,577 tons	181,897
Feldspar	1,087 tons	7,609
Granite		30,210
Mineral water	58,115 gals.	16,672
Silica	1,877 tons	11,391
Stone, miscellaneous		400,560
Other minerals*		2,059,806
Total value		$3,243,917

*Includes cement, coal, fluorite (optical).

SACRAMENTO.

Area: 983 square miles.
Population: 90,978 (1920 census).
Location: North-central portion of state.

Sacramento stands sixteenth among the counties of the state as a mineral producer, the output, principally gold, for 1922, being valued at $2,189,562, as compared with the 1921 production, worth $2,394,894. In regard to gold output alone, this county ranks fifth, being exceeded only by Nevada, Yuba, Amador and Calaveras counties, the Sacramento product coming from the dredges. Its mineral resources include: Brick, clay, gold, natural gas, platinum, silver, and miscellaneous stone.

Commercial production for 1922 was as follows:

Substance	Value
Brick and tile	$259,263
Gold	1,350,749
Granite	51,500
Silver	3,392
Stone, miscellaneous	412,667
Other minerals*	111,991
Total value	$2,189,562

*Includes natural gas and platinum.

SAN BENITO.

Area: 1,392 square miles.
Population: 8,995 (1920 census).
Location: West-central portion of state.

Although nineteenth among the counties of the state in regard to value of total mineral production, San Benito led for some years in one important branch of the mineral industry, namely, quicksilver. In spite of the shut-down of the quicksilver mines in 1921-1922, San Benito County retained its position on account of cement, which showed an increased yield over the 1921 figures.

Its other mineral resources, many of them undeveloped, include: Antimony, asbestos, bituminous rock, chromite, coal, dolomite, gems, gypsum, limestone, magnesite, mineral water, and miscellaneous stone.

Commercial production for 1922 was as follows:

Substance	Amount	Value
Dolomite	6,650 tons	$30,100
Stone, miscellaneous		259,805
Other minerals*		1,504,343
Total value		$1,794,248

*Includes asbestos, cement, magnesite, mineral water, quicksilver.

SAN BERNARDINO.

Area: 20,157 square miles.
Population: 73,401 (1920 census).
Location: Southeastern portion of state.

San Bernardino, by far the largest county in the state, in area, ranks fifth as regards the value of its mineral output for 1922 with a total

of $8,547,900, as compared with the 1921 total of $9,375,540. The decrease is due to silver and cement.

San Bernardino for several years (except 1918) has led all other counties in the state in point of variety of minerals, producing commercially during 1922 a total of 19 different substances.

This county, consisting largely of mountain and desert country, is highly mineralized, the following being included among its resources: Asbestos, barytes, borax, brick, cement, clay, copper, gems, gold, granite, gypsum, iron, lead, limestone, manganese, marble, mineral paint, mineral water, nitre, potash, salt, soapstone, soda, miscellaneous stone, strontium, talc, tungsten, vanadium, and zinc.

Commercial production for 1922 was as follows:

Substance	Amount	Value
Cement	2,770,953 bbls.	$4,156,430
Copper	13,452 lbs.	1,816
Gold		125,728
Lead	11,188 lbs.	615
Limestone	2,200 tons	7,800
Salt	12,222 tons	54,259
Silver		2,374,948
Other minerals*		1,826,304
Total value		$8,547,900

*Includes borates, calcium chloride, fuller's earth, gems, gypsum, lime, mineral water, potash, soda, talc, miscellaneous stone.

SAN DIEGO.

Area: 4,221 square miles.
Population: 112,248 (1920 census).
Location: Extreme southwest corner of state.

San Diego ranks twenty-sixth in the total value of its mineral output, and advanced to second place in point of variety with a record of 18 different commercial minerals for the year. The value for 1922 equaled $656,807, as compared with the 1921 output worth $501,393. In 1918, for the only time in several years, there was no production of gems, in which San Diego County has led the state. Aside from minerals commercially produced, as shown below, San Diego County contains occurrences of bismuth, lithia, marble, nickel, soapstone, and tin. Potash has been produced from kelp.

A development of recent years is the shipping of pebbles for grinding mills.

Commercial production for 1922 was as follows:

Substance	Amount	Value
Clay and clay products		$93,045
Feldspar	3,500 tons	29,500
Gems		400
Granite		35,673
Mineral water	71,781 gals.	9,262
Stone, miscellaneous		355,810
Other minerals*		133,117
Total value		$656,807

*Includes fuller's earth, gold, lithia, magnesium salts, marble, salt, silica, silver.

SAN FRANCISCO.

Area: 43 square miles.
Population: 506,676 (1920 census).

Surprising as it may appear at first glance. San Francisco County is listed among the mineral producing sections of the state, actual production consisting mainly of crushed rock. sand and gravel. Small quantities of various valuable mineral substances are found here, including cinnabar, gypsum, lignite. and magnesite, none, however, in paying quantities. Some pumice has been produced.

In forty-eighth place, commercial production for 1922 was as follows:

Substance	Value
Unapportioned*	$65,409

*Includes pumice and miscellaneous stone.

SAN JOAQUIN.

Area: 1,448 square miles.
Population: 79,905 (1920 census).
Location: Central portion of state.

San Joaquin County reported a mineral production for the year 1922 having a total value of $473,395, as compared with the 1921 output, worth $474,378.

Comparatively few mineral substances are found here, the chief ones being brick, clay, manganese, natural gas, glass-sand, and miscellaneous stone. Gold, platinum, and silver have been obtained by dredging in the Mokelumne River, which forms the boundary between this county and Amador on the northeast.

In twenty-eighth place, commercial production for 1922 was as follows:

Substance	Amount	Value
Brick and clay		$314,269
Natural gas	199,389 M. cu. ft.	62,454
Other minerals*		96,672
Total value		$473,395

*Includes manganese ore and miscellaneous stone.

SAN LUIS OBISPO.

Area: 3,334 square miles.
Population: 21,893 (1920 census).
Location: Bordered by Kern County on the east and the Pacific Ocean on the west.

The total value of the mineral production of San Luis Obispo County in 1922 was $141,470, as compared with the 1921 output, worth $129,791, the increase being due to miscellaneous stone. Among its mineral resources, both developed and undeveloped, are: Asphalt, bituminous rock, brick, chromite, coal, copper, gypsum, infusorial earth, iron, limestone, marble, mineral water, onyx, petroleum, quicksilver, soda, and miscellaneous stone.

In forty-second place, commercial production for 1922 was as follows:

Substance	Amount	Value
Petroleum	33,856 bbls.	$31,892
Stone, miscellaneous		107,000
Other minerals*		2,578
Total value		$141,470

*Includes chromite, diatomaceous earth, mineral water.

SAN MATEO.

Area: 447 square miles.
Population: 36,781 (1920 census).
Location: Peninsula, adjoined by San Francisco on the north.

San Mateo's most important mineral products are stone and salt, the last-named being derived by evaporation from the waters of San Francisco Bay. The total value of all mineral production during 1922 equaled $243,984, as compared with the 1921 figures of $257,092, the decrease being due to salt.

Small amounts of barytes, chromite, infusorial earth, and quicksilver have been noted in addition to the items of economic value given below.

Bricks have also been produced commercially.

In thirty-fifth place, commercial production for 1922 was as follows:

Substance	Amount	Value
Salt	32,428 tons	$149,302
Stone, miscellaneous		60,009
Other minerals*		34,984
Total value		$243,984

*Includes magnesium salts, petroleum, potash.

SANTA BARBARA.

Area: 2,740 square miles.
Population: 41,097 (1920 census).
Location: South-western portion of state, joining San Luis Obispo on the south.

Santa Barbara County owes its position of seventh in the state in regard to its mineral output to the presence of productive oil fields within its boundaries. The total value of its mineral production during the year 1922 was $4,613,358, as compared with the 1921 output of $10,190,929, the decrease being due to lower petroleum prices.

Aside from the mineral substances listed below, Santa Barbara County contains asphalt, diatomaceous earth, gilsonite, gypsum, magnesite, and quicksilver in more or less abundance.

Commercial production for 1922 was as follows:

Substance	Amount	Value
Mineral water	110,552 gals.	$52,269
Natural gas	1,876,900 M. cu. ft.	167,290
Petroleum	3,931,155 bbls.	3,974,398
Stone, miscellaneous		72,300
Other minerals*		347,101
Total value		$4,613,358

*Includes bituminous rock, brick, diatomaceous earth, potash, sandstone, shale oil.

SANTA CLARA.

Area: 1,328 square miles.
Population: 100,588 (1920 census).
Location: West-central portion of state.

Santa Clara County reported a mineral output for 1922 of $894,036, as compared with the 1921 figures of $750,708. the increase being due to brick. magnesite, and miscellaneous stone.

This county, lying largely in the Coast Range Mountains, contains a wide variety of mineral substances, including brick, chromite, clay, limestone, magnesite, manganese, mineral water, petroleum, quicksilver, soapstone, and miscellaneous stone. It led in quicksilver yield for the year.

In twenty-third place, commercial production for 1922 was as follows:

Substance	Amount	Value
Brick	11,409 M.	$150,057
Clay (pottery)	3,826 tons	7,372
Magnesite	28,650 tons	301,875
Mineral water	3,500 gals.	325
Stone, miscellaneous		235,125
Other minerals*		199,282
Total value		$894,036

*Includes limestone marl, petroleum, quicksilver.

SANTA CRUZ.

Area: 435 square miles.
Population: 26.269 (1920 census).
Location: Bordering Pacific Ocean, just south of San Mateo County.

The mineral output of Santa Cruz County, a portion of which is itemized below, amounted to a total value of $3,608.805, giving the county a standing of eighth among all others in the state in this regard.

The decrease from the 1921 figure of $4,080,885, is due mainly to lower cement prices during the year.

The commercial production for 1922 was as follows:

Substance	Amount	Value
Lime	174,490 bbls.	$235,802
Limestone	4,581 tons	20,534
Stone, miscellaneous		7,398
Other minerals*		3,345,071
Total value		$3,608,805

*Includes bituminous rock, cement, potash.

SHASTA.

Area: 3,858 square miles.
Population: 13,311 (1920 census).
Location: North-central portion of state.

Shasta County stood twenty-first in California among the mineral producing counties for 1922. with an output valued at $1,513,591. as compared with the 1921 production worth $841,062, the increase being

due to copper, gold, and zinc. The marked decrease in 1918-1921 was due to the falling off in the output of copper, the large plants of the Mammoth and Mountain copper companies being shut down. Not taking petroleum into account, Shasta for a number of years led all of the counties by a wide margin; but in 1919-1921 was passed by San Bernardino, Inyo, Yuba, Plumas, Amador, Nevada, and Sacramento, among the 'metal' counties.

Shasta's mineral resources include: Asbestos, barytes, brick, chromite, coal, copper, gold, iron, lead, lime, limestone, mineral water, molybdenum, pyrite, silver, soapstone, miscellaneous stone, and zinc.

Lassen Peak is located in southeastern Shasta County.

Commercial production for 1922 was as follows:

Substance	Amount	Value
Copper	1,827,875 lbs.	$246,763
Gold		393,034
Platinum	496 fine oz.	57,458
Silver		26,901
Stone, miscellaneous		65,525
Other minerals*		723,910
Total value		$1,513,591

*Includes asbestos, barytes, iron ore, lead, pyrites, zinc.

SIERRA.

Area: 923 square miles.

Population: 1,783 (1920 census).

Location: Eastern border of state, just north of Nevada County.

Sierra County reported a mineral production of $1,770,626 mainly of gold and silver, during the year 1922, as compared with the 1921 output, worth $620,361, the increase being due to gold. Considering gold output alone this county stands fourth, having passed Calaveras and Sacramento; and as to total mineral yield, twentieth.

Aside from the metals itemized below, Sierra County contains deposits of asbestos, chromite, copper, iron, lead, platinum, serpentine, and talc.

Commercial production for 1922 was as follows:

Substance	Value
Gold	$1,753,242
Silver	14,484
Stone, miscellaneous	2,900
Total value	$1,770,626

SISKIYOU.

Area: 6,256 square miles.

Population: 18,545 (1920 census).

Location: Extreme north-central portion of state, next to Oregon boundary.

Siskiyou, fifth county in California in regard to size, located in a highly mineralized and mountainous country, ranks forty-fourth in regard to the value of its mineral output for 1922. The increase in 1922 was due mainly to gold.

Although the county is traversed by a transcontinental railroad in a north and south line, the mineral-bearing sections are almost without

exception far from transportation and other facilities. A large part of the county is accessible by trail only. Future development and exploitation will increase the productiveness of this part of the state to a considerable degree.

Mount Shasta is located in Siskiyou County.

Among Siskiyou's mineral resources are: Chromite, clay, coal, copper, gems, gold, lead, limestone, manganese, marble, mineral water, pumice, quicksilver, sandstone, silver, and miscellaneous stone.

Commercial production for 1922 was as follows:

Substance	Value
Gold	$75,105
Silver	612
Stone, miscellaneous	21,726
Other minerals*	4,020
Total value	$101,463

*Includes limestone and mineral water.

SOLANO.

Area: 822 square miles.
Population: 40,602 (1920 census).
Location: Touching San Francisco Bay on the northeast.

Solano, while mostly valley land, produced mineral substances during the year 1922 to the total value of $3,108,114, ranking eleventh among the counties of the state, the increase over the 1921 figures of $3,030,198 being due to cement. Among her mineral resources are: Brick, cement, clay, fuller's earth, limestone, mineral water, natural gas, onyx, quicksilver, salt, and miscellaneous stone.

Commercial production for 1922 was as follows:

Substance	Value
Stone, miscellaneous	$103,394
Other minerals*	3,004,720
Total value	$3,108,114

*Includes cement, mineral water, onyx.

SONOMA.

Area: 1,577 square miles.
Population: 51,990 (1920 census).
Location: South of Mendocino County, bordering on the Pacific Ocean.

Sonoma ranked thirty-seventh among the counties of California during the year 1922, with a mineral production of $221,941, as compared with its 1921 output worth $175,551. More paving blocks have been turned out here than in any other section of the state, but this industry has now practically ceased, owing to the construction of smooth-surface pavements both in the cities and on the highways.

Among Sonoma's mineral resources are: Brick, chromite, clay, copper, graphite, infusorial earth, magnesite, manganese, marble, mineral paint, mineral water, quicksilver, and miscellaneous stone.

Commercial production for 1922 was as follows:

Substance	Amount	Value
Mineral water	35,843 gals.	$9,108
Stone, miscellaneous		162,679
Other minerals*		50,154
Total value		$221,941

*Includes clay (pottery), gems, quicksilver.

STANISLAUS.

Area: 1,450 square miles.
Population: 43,557 (1920 census).
Location: Center of state, bounded on south by Merced County.

Gold has usually been the chief mineral product of Stanislaus County, but it was exceeded in 1918–1919 by manganese, and in 1921–1922 by miscellaneous stone. Brick, clay, gypsum, mineral paint, quicksilver, and silver are found here to some extent as well. This county for 1922 ranks twenty-ninth in the state in regard to value of minerals, with an output of $452,167, as compared with $236,207 in 1921, the increase being due to gold and miscellaneous stone. Gold, platinum, and silver are obtained by dredging.

Commercial production for 1922 was as follows:

Substance	Amount	Value
Magnesite	2,400 tons	$35,475
Stone, miscellaneous		299,962
Other minerals*		116,730
Total value		$452,167

*Includes gold, manganese ore, mineral paint, platinum, silver.

SUTTER.

Area: 608 square miles.
Population: 10,115 (1920 census).
Location: Bounded by Butte County on the north and Sacramento on the south.

Sutter is one of only two counties in the state which for a number of years reported no commercial output of some kind of mineral substance. In 1917 some crushed rock was taken out, from the Marysville Buttes, but there was no production in 1918, nor 1919. There has been some utilization of natural gas. The 1922 mineral yield was valued at $97, being concealed under 'unapportioned.' Both coal and clay exist here, but deposits of neither mineral have been placed on a productive basis.

TEHAMA.

Area: 2,893 square miles.
Population: 12,882 (1920 census).
Location: North-central portion of the state, bounded on the north by Shasta.

Tehama stands fifty-fourth among the mineral producing counties of the state for 1922, when its output was valued at $9,388, as compared with the 1921 yield worth $30,820.

Among its mineral resources are listed: Brick, chromite, copper, gold, manganese, marble, mineral water, salt, and miscellaneous stone.

The 1922 yield was distributed as follows:

Substance	Value
Unapportioned*	$9,388

*Includes brick and miscellaneous stone.

TRINITY.

Area: 3,166 square miles.
Population: 2,551 (1920 census).
Location: Northwestern portion of state.

Trinity, like its neighbor, Siskiyou County, requires transportation facilities to further the development of its many and varied mineral resources. Deposits of asbestos, barytes, chromite, copper, gold, mineral water, platinum, quicksilver, silver, and building stone are known here, but with the exception of gold, chromite, copper, quicksilver, and platinum, very little active production of these mineral substances has been made as yet. The 1922 output of $197,937 shows a decrease from the 1921 figure of $456,882, due to gold:

Substance	Amount	Value
Gold		$182,918
Platinum	12 fine oz.	1,223
Silver		2,432
Stone, miscellaneous		5,677
Other minerals		5,687
Total value		$197,937

TULARE.

Area: 4,856 square miles.
Population: 59,031 (1920 census).
Location: Bounded by Inyo on the east, Kern on the south, Fresno on the north.

Tulare stands thirty-second on the list of mineral-producing counties, the decrease from the 1920 value being due mainly to miscellaneous stone. This county's mineral resources, among others, are: Brick, clay, copper, feldspar, graphite, gems, limestone, magnesite, marble, quartz, glass-sand, soapstone, miscellaneous stone, and zinc. Tulare for a number of years led the state in magnesite output, except in 1918 when it was passed by Napa County, and in 1921–1922 by Santa Clara.

Commercial production for 1922 was as follows:

Substance	Amount	Value
Magnesite	17,223 tons	$181,842
Natural gas	380 M. cu. ft.	190
Stone, miscellaneous		151
Other minerals*		189,662
Total value		$371,845

*Includes brick and tile, granite, limestone.

TUOLUMNE.

Area: 2,190 square miles.
Population: 7,768 (1920 census).
Location: East-central portion of state—Mother Lode District.

Tuolumne ranks twenty-fifth among counties of the state relative to its total value of mineral output for 1922. This county ranks first as a producer of marble in the state. The increase in the year's valuation to $764,938 for 1922, over the 1921 figure of $554,483 was due to gold and to large amounts of crushed rock, sand and gravel being used on the Hetch Hetchy project of the city of San Francisco.

Chromite, clay, copper, gold, lead, limestone, marble, mineral paint, platinum, soapstone, silver, and miscellaneous stone are among its mineral resources.

Commercial production for 1922 was as follows:

Substance	Value
Gold	$222,366
Silver	2,976
Stone, miscellaneous	246,460
Other minerals*	293,136
Total value	$764,938

*Includes dolomite, granite, lime, magnesite, marble.

VENTURA.

Area: 1,878 square miles.
Population: 28,724 (1920 census).
Location: Southwestern portion of state, bordering on Pacific Ocean.

Ventura is the sixth county in the state in respect to the value of its mineral production for 1922, the exact figure being $5,837,078, as compared with the output for 1921, worth $6,245,269, the decrease being due to lower petroleum prices.

The highest gravity petroleum produced in the state is found here.

Among its other mineral resources are: Asphalt, borax, brick, clay, mineral water, natural gas, sandstone, and miscellaneous stone.

Commercial production for 1922 was as follows:

Substance	Amount	Value
Natural gas	3,583,818 M. cu. ft.	$536,502
Petroleum	2,933,685 bbls.	5,236,628
Stone, miscellaneous		62,888
Other minerals*		1,060
Total value		$5,837,078

*Includes mineral paint and sandstone.

YOLO.

Area: 1,014 square miles.
Population: 17,105 (1920 census).
Location: Sacramento Valley, bounded by Sutter on the east and Colusa on the north.

The mineral production from Yolo County during the year 1922 consisted mainly of miscellaneous stone, valued at $13,431, ranking it

in fifty-third place. Deposits of undetermined value of iron and sandstone have been discovered within the confines of this county. Quicksilver has also been produced.

YUBA.

Area: 639 square miles.
Population: 10,375 (1920 census).
Location: Lies west of Sierra and Nevada counties; south of Plumas.

Yuba is thirteenth of the mineral-producing counties of the state, and second in regard to gold output for 1922, losing its lead of three years to Nevada County in that metal. Iron and clay deposits have been reported in this county aside from the following commercial production shown for the year 1922. The decrease from the 1921 figure of $4,852,266 was due to gold obtained by the dredgers, which also yield silver and platinum. The 1921 dredge yield was a record for the county.

The 1922 production of Yuba County was distributed as follows:

Substance	Amount	Value
Gold		$2,492,948
Platinum	115 fine oz.	11,077
Silver		8,222
Stone, miscellaneous		75,969
Other minerals		100
Total value		$2,588,316

PUBLICATIONS OF THE CALIFORNIA STATE MINING BUREAU.

During the past forty-two years, in carrying out the provisions of the organic act creating the California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the state, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have often been limited, many of the reports and bulletins mentioned were printed in limited editions which are now entirely exhausted.

Copies of such publications are available, however, in the Bureau's offices in the Ferry Building, San Francisco; Pacific Finance Building, Los Angeles; in Santa Maria; Santa Paula; Coalinga; Taft; Bakersfield; Auburn, and Redding. They may also be found in many public, private and technical libraries in California and other states, and foreign countries.

A catalog of all publications of the Bureau, from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained by addressing any of the offices of the State Mining Bureau and enclosing the requisite amount in the case of publications that have a list price. The Bureau is authorized to receive only coin, stamps or money orders, and it will be appreciated if remittance is made in this manner rather than by personal check.

The prices noted include delivery charges to all parts of the United States. Money orders should be made payable to the State Mining Bureau.

REPORTS.

Asterisks (**) indicate the publication is out of print.

	Price
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
**Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. By Henry G. Hanks	----
**Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr.	----
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	----
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps. William Irelan, Jr.	$1.00
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report, Biennial Period, 1913–1914, Fletcher Hamilton:	
**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	----
Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper	.50
Mines and Mineral Resources, Del Norte, Humboldt, and Mendocino Counties, 59 pp., paper	.25
Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pp., paper	.50
Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper	.35
**Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper	----
Fourteenth Report of the State Mineralogist, for the Biennial Period 1913–1914, Fletcher Hamilton, 1915:	
A General Report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou, and Trinity Counties, 974 pp., 275 illustrations, cloth	2.00
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Mines and Mineral Resources, Monterey, San Benito, San Luis Obispo, Santa Barbara, and Ventura Counties, 183 pp., paper — .65

Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper — .65

Fifteenth Report of the State Mineralogist, for the Biennial Period 1915–1916, Fletcher Hamilton, 1917:

A general Report on the Mines and Mineral Resources of Alpine, Inyo, Mono, Butte, Lassen, Modoc, Sutter, Tehama, Placer, Sacramento, Yuba, Los Angeles, Orange, Riverside, San Benito, San Luis Obispo, Santa Barbara, Ventura, San Bernardino and Tulare Counties, 990 pp., 413 illustrations, cloth — 3.75

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Mines and Mineral Resources of Sierra County, 144 pp., paper — .50

Seventeenth Report of the State Mineralogist, 1920, Mining in California During 1920, Fletcher Hamilton; 562 pp., 71 illustrations, cloth — 1.75

Eighteenth Report of the State Mineralogist, 1922, Mining in California, Fletcher Hamilton. Chapters published monthly beginning with January, 1922:

**January, **February, March, April, May, June, July, August, September, October, November, December, 1922 — Free

Nineteenth Report of the State Mineralogist, Mining in California, Fletcher Hamilton and Lloyd L. Root, January, February, March, September — Free

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Summary of Operations—California Oil Fields. Published monthly, beginning April, 1919:

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**Catalogue of the State Museum of California, Volume II, being the collection made by the State Mining Bureau from April 16, 1881, to May 5, 1884. 220 pp.	----
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**Catalogue of West North American and Many Foreign Shells with Their Geographical Ranges, by J. G. Cooper. Printed for the State Mining Bureau, April, 1894	----
**Report of the Board of Trustees for the four years ending September, 1900. 15 pp. Paper	----
Bulletin. Reconnaissance of the Colorado Desert Mining District. By Stephen Bowers, 1901. 19 pp. 2 illustrations. Paper	Free
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Map of Forest Reserves in California—	
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**Mineral and Relief Map of California	----
**Map of El Dorado County, Showing Boundaries, National Forests	----
**Map of Madera County, Showing Boundaries, National Forests	----
**Map of Placer County, Showing Boundaries, National Forests	----
**Map of Shasta County, Showing Boundaries, National Forests	----
**Map of Sierra County, Showing Boundaries, National Forests	----
**Map of Siskiyou County, Showing Boundaries, National Forests	----
**Map of Tuolumne County, Showing Boundaries, National Forests	----
**Map of Mother Lode Region	----
**Map of Desert Region of Southern California	----
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Map of Copper Deposits in California	.05
**Map of Calaveras County	----
Map of Plumas County	.25
**Map of Trinity County	----
Map of Tuolumne County	.25
Geological Map of Inyo County. Scale 1 inch equals 4 miles	.60
Map of California accompanying Bulletin No. 89, showing generalized classification of land with regard to oil possibilities. Map only, without Bulletin	.25
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These maps are revised from time to time as development work advances and ownerships change.

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Map No. 25—Kern River Oil Field	.75
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Map No. 28—Torrance, Los Angeles County	.75

DETERMINATION OF MINERAL SAMPLES.

Samples (limited to three at one time) of any mineral found in the state may be sent to the Bureau for identification, and the same will be classified free of charge. No samples will be determined if received from points outside the state. It must be understood that no assays, or quantitative determinations will be made. Samples should be in lump form if possible, and marked plainly with name of sender on outside of package, etc. No samples will be received unless delivery charges are prepaid. A letter should accompany sample, giving locality where mineral was found and the nature of the information desired.

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